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MACROPHAGE-DERIVED INFLAMMATORY MEDIATOR (MIP-2)RELATED PUBLICATIONS

- 5 The Applicants are authors or co-authors of several articles directed to the subject matter of the present invention. These articles supplement those articles listed in U.S. Patent No. 4,603,106, which earlier articles are incorporated herein by reference. (1)
- 10 [Applicant Cerami co-authored with B. Beutler, J. Mahoney, N. Le Trang and P. Pekala] "Purification of Cachectin, a Lipoprotein Lipase-Suppressing Hormone Secreted By Endotoxin-Induced RAW 264.7 Cells", J. EXP. MED. 161:984-995 (May, 1985); (2) [Applicant Cerami
- 15 co-authored with M. Kawakami, J.R. Mahoney, N. Le Trang, W. Vine, and Y. Ikeda] "Lipopolysaccharide-Treated RAW 264.7 Cells Produce a Mediator Which Inhibits Lipoprotein Lipase in 3T3-L1 Cells", J. IMMUNOL. 134 (3):1673-1675 (March, 1985); (3) [Applicant Cerami co-authored with
- 20 P.J. Hotez, N. Le Trang, and A.H. Fairlamb] "Lipoprotein Lipase Suppression in 3T3-L1 Cells by a Haematoprotazoan-Induced Mediator From Peritoneal Exudate Cells." PARASITE IMMUNOL. (Oxf.) 6:203 (1984); (4) [Applicant Cerami co-authored with B. Beutler, D.
- 25 Greenwald, J. D. Hulmes, M. Chang Y.-C.E. Pan, J. Mathison and R. Ulevitch] "Identity of Tumor Necrosis Factor and Macrophage-Secreted Factor Cachectin", NATURE 316:552-554 (1985); (5) [Applicant Cerami co-authored with B. Beutler, F.M. Torti, B. Dieckmann and G.M.
- 30 Ringold] "A Macrophage Factor Inhibits Adipocyte Gene Expression: An In Vitro Model of Cachexia" SCIENCE 229:867-869 (1985); (6) [Applicant Cerami co-authored with B. Beutler and I.W. Milsark] "Passive Immunization Against Cachectin/Tumor Necrosis Factor (TNF) Protects
- 35 Mice From the Lethal Effect of Endotoxin", SCIENCE 229:869-871 (1985); (7) [Applicants Cerami, Wolpe and Sherry co-authored with B. Beutler, G. Davatelis, D. G. Hesse, H. T. Nbuyen, L. I. Moldawer, C. F. Nathan and S.

F. Lowry], "Macrophages Secrete a Novel Heparin-Binding Protein with Inflammatory and Neutrophil Chemokinetic Properties", J. EXP. MED. 167:570-581 (1988); (8) [Applicants Wolpe, Cerami and Tekamp-Olson co-authored with G. Davatelis, K. Hermesen, C. Luedke, C. Gallegos, D. Coit and J. Merryweather], "Cloning and Characterization of a cDNA for Murine Macrophage Inflammatory Protein (MIP), A Novel Monokine with Inflammatory and Chemokinetic Properties", J. EXP. MED., 17:1939-1944 (June, 1988); (9) [Applicants co-authored with C. Gallegos, D. Bauer, G. Davatelis, F. Masiarz and D. Coit], "Resolution of the Two Components of Macrophage Inflammatory Protein 1, and Cloning and Characterization of One of Those Components, MIP-1B", J. EXP. MED. 168:2251-2259 (December, 1988); and (10) [Applicants Wolpe, Cerami and Sherry co-authored with D. Juers, G. Davatelis, and R. Yurt], "Identification and Characterization of Macrophage Inflammatory Protein 2", PROC. NATL. ACAD. SCI. USA 86:612-616 (January, 1989).

The research leading to the present invention was funded in part by grants from the National Institutes of Health and the Rockefeller Foundation.

25 BACKGROUND OF THE INVENTION

30 The present invention is generally directed to materials and associated methods for the analysis and treatment of the effects and corresponding operation of invasive stimuli such as infection upon animal hosts, and in particular, is concerned with the identification of materials which may participate in the host response to such invasive stimuli.

35 Several common physiological and biochemical derangements have been observed in various mammalian hosts responding to a variety of invasive stimuli such as bacterial, viral, or protozoal infection; tumors; or endotoxemia; as

well as in idiopathic states. For example, these responses include fever, leukocytosis, hyperlipidemia, reduced food intake (anorexia), reduced activity, wasting (cachexia), and other modifications in muscle, white blood cell and liver metabolism. In particular, recent studies aimed at elucidating the biochemical mechanism of cachexia in rabbits infected with Trypanosoma brucei noted that animals with a minimal parasite burden became moribund and exhibited an extreme hypertriglyceridemia, with a marked elevation of plasma very low density lipoprotein (VLDL). See C.A. Rouser and A. Cerami, MOL. BIOCHEM. PARASITOL. 1:31-38 (1980). The hypertriglyceridemic state was remarkable in view of the severe wasting diathesis that accompanied this experimental infection. The elevation of plasma VLDL was shown to result from a clearing defect, caused by a loss of peripheral tissue lipoprotein lipase (LPL) activity.

Reduced LPL activity has been observed by others, and it has been noted that this condition has existed when the human body was in shock. See E.B. Man, et al., "The Lipids of Serum and Liver in Patients with Hepatic Diseases", CLIN. INVEST. 24 at 623, et seq. (1945); See also John I. Gallin, et al., "Serum Lipids in Infection", N. ENGL. J. MED. 281 at 1081-1086 (November 13, 1969); D. Farstchi, et al., "Effects of Three Bacterial Infections on Serum Lipids of Rabbits", J. BACTERIOL. 95 at 1615, et seq. (1968); S.E. Grossberg, et al., "Hyperlipaemia Following Viral Infection in the Chicken Embryo: A New Syndrome", NATURE (London) 208 at 954, et seq. (1965); Robert L. Hirsch, et al., "Hyperlipidemia, Fatty Liver and Bromsulphophthalein Retention in Rabbits Injected Intravenously with Bacterial Endotoxin", J. LIPID. RES. at 563-568 (1964); and Osamu Sakaguchi, et al., "Alternations of Lipid Metabolism in Mice Injected With Endotoxins", MICROBIOL. IMMUNOL. 23 (2) at 71-85 (1979); R.F. Kampschmidt, "The Activity of Partially Purified Leukocytic Endogenous Mediator in Endotoxin Resistant

C3H/HeJ Mice", J. LAB. CLIN. MED. 95 at 616, et seq. (1980); and Ralph F. Kampschmidt, "Leukocytic Endogenous Mediator", J. RET. SOC. 23 (4) at 287-297 (1978).

5 Additionally, publications are known by the Applicants that discuss the identification and existence of "mediators" that appear to be involved in the host response to infection; and in particular, the following articles, the texts of which are incorporated herein by
10 reference, are listed: Sipe, J.D., et al., J. EXP. MED., 150:597-606 (1979); and Barney, C.C., et al., LIPTON, J.M. (Ed.), FEVER: INTERNATIONAL SYMPOSIUM, Dallas, Texas, April 11-12, 1979 XII + 263P. Raven Press: New York, Illus. ISBN 0-89004-451-1 (08877), 0 (0),
15 pp.111-122 (1980); and Dinarello, C.A., "Human Leukocytic Pyrogen: Purification and Development of a Radioimmunoassay", PROC. NATL. ACAD. SCI. USA, 74(10) at 4624-4627 (October, 1977). All of the factors identified and investigated by each of the authors in the above
20 noted articles and the articles authored or co-authored by Kampschmidt have been determined to comprise a single grouping of factors which has been identified as interleukin-1 (IL-1). This determination has been documented in an article by Charles A. Dinarello,
25 published in REVIEWS OF INFECTIOUS DISEASES, at Volume 6, No. 1 (January-February, 1984), the text of which is also incorporated herein by reference.

A similar deficiency of LPL activity was noted by
30 Applicants in C3H/HeN mice after administration of Escherichia coli lipopolysaccharide (LPS). In contrast, the loss of LPL activity was not demonstrable in C3H/HeJ mice, which are genetically resistant to LPS. This resistance to endotoxin-induced LPL deficiency could be
35 circumvented by the administration of serum obtained from endotoxin-sensitive animals that had been injected with LPS two hours previously. Similarly, resistance could be overcome by injecting conditioned medium from

endotoxin-stimulated thioglycollate-elicited peritoneal macrophages, obtained from sensitive mice. These findings were set forth in full detail in Application Serial No. 414,098, now U.S. Patent No. 4,603,106, the disclosure of which is incorporated herein by reference.

The above work was prompted by the belief that the "mediator" or "mediators" existed and were suspected to have a significant effect upon general anabolic activity of energy storage cells in the animal host. It was suspected that such "mediator" exerted a depressive effect upon the activity of certain anabolic enzymes, whose reduced activity was observed for instance, where the hosts enter the condition known as shock, as in response to infectious invasion. Resultingly, the relationship of the mediator produced by endotoxin-stimulated peritoneal mouse exudate cells, upon endotoxin-sensitive and endotoxin-insensitive mice alike, and the development through such investigation of a reagent for the measurement of anabolic enzyme activity was set forth in first filed abandoned application Serial No. 299,932, incorporated herein by reference.

Further investigation of this system was made in conjunction with the 3T3-L1 "preadipocyte" model system, and the corresponding development of methods and associated materials for the development of antibodies to the "mediator" and other diagnostic procedures was then set forth in application Serial No. 351,290, also incorporated herein by reference and now abandoned. Thereafter, in subsequent application Serial No. 414,098, now U.S. Patent No. 4,603,106, it was established that the mediator substance derived from the endotoxin stimulation of macrophage cells exhibited the activities of suppressing the anabolic enzymes lipoprotein lipase, acetyl Coenzyme A Carboxylase and fatty acid synthetase, and further, inhibited the growth and differentiation of erythroid-committed cells.

Additional work set forth in articles (1) and (4) by Beutler et al., and Application Serial No. 766,852, the disclosure of which is incorporated herein by reference, has resulted in the discovery that the earlier identified mediator substance contained a further protein component which possesses a number of activities, which distinguished it from both the mediator substance and the other factors identified in the art and known as interleukin-1 and interleukin-2. Further work set forth in articles (7)-(9) and Parent Application Serial No. 104,827, the disclosure of which is incorporated herein by reference, established the presence of an additional factor (MIP-1) in the mediator substance which factor demonstrates a distinguishable profile of activities.

Subsequently, the present inflammatory cytokine MIP-2 was isolated and purified and its distinctive activities elucidated as set forth in immediate Parent Application Serial No. 240,079. Since that time, the complete sequence of the present cytokine has been determined following the cloning of its cDNA, and expression of the cytokine has been pursued. The present application is intended to include the additional information regarding this cytokine that is now available as a result of the investigations of the inventors herein.

MIP-2 is a member of a homologous multigene family. Members of this family that have highest homology in protein sequence (generally predicted from cloned cDNA) include MGSA and KC. MGSA (Richmond et al., EMBO J. 7: 2025 (1988) is an autocrine growth factor with potent mitogenic activity secreted by human melanoma cells and is the product of the human gro gene (Anisowicz et al., PROC. NAT. ACAD. SCI. USA 84:7188 (1987). MGSA has 61.6% identity in amino acid sequence to MIP-2; the predicted protein sequence of the hamster homolog of MGSA has 68.4% identity to MIP-2. The murine KC gene product is induced

by PDGF and is thought to be the murine homolog of the human MGSA/gro gene (66.3% amino acid identity to MIP-2).

The present applicants know of no prior art on the
5 expression of recombinant MIP-2 although Lipes et al.,
(PROC. NATL. ACAD. USA 85: 9704, 1988) described
baculovirus expression of Act-2 cDNA, a putative human
homolog of murine MIP-1 β , to show that the protein
encoded was secreted and to identify the mature N-
10 terminal sequence.

Members of the MIP-1 and MIP-2 gene families have been
expressed but the pertinence of these results to MIP-2
expression is questionable. The literature is summarized
15 as follows. JE, a cDNA that encodes a protein with
homology to MIP-1 α and MIP-1 β , has been expressed in COS-
1 cells to confirm that it encodes a polypeptide core of
about 12 kDa (Rollins et al., PROC. NATL. ACAD. SCI. USA
85: 3738, 1988). KC, a cDNA that encodes a protein with
20 homology to MIP-2, has been expressed in COS-1 cells to
show that it encodes a secreted protein by Oguendo et
al., J. BIOL. CHEM. 264: 4133 (1989). Connective tissue
activating peptide-III (CTAP) reported by Mullenbach et
al., J. BIOL. CHEM. 261: 719 (1986) and IP-10, reported
25 by Luster and Ravetch, J. EXP. MED. 166: 1084 (1987) both
members of the MIP-2 gene family, have been expressed as
an α -factor fusion in yeast and in E. coli,
respectively. Finally, Lindley et al., PROC. NAT. ACAD.
SCI. USA 85: 9199 (1985) have expressed NAF, a member of
30 the MIP-2 family, in E. coli. After purification and
renaturation, this recombinant protein was found to have
the same bioactivity identified for the native molecule.

SUMMARY OF THE INVENTION

35

In accordance with the first aspect of the present
invention, the inflammatory cytokine MIP-2 isolated from
the mediator substance is disclosed, and comprises a

protein that has been purified and is cationic under basic physiological conditions. The inflammatory cytokine of the present invention exhibits the ability to bind to heparin, even at high salt concentrations, to induce localized inflammation characterized by polymorphonuclear cell infiltration when administered subcutaneously and is an extremely active chemotactic agent while inducing little or no chemokinetic activity. The present inflammatory cytokine however, lacks certain activities common to other factors that have been isolated from the mediator substance disclosed in U.S. Patent No. 4,603,106.

In particular, the present inflammatory cytokine lacks the ability to suppress the activity of the anabolic enzyme lipoprotein lipase (LPL), and is unable to cause the cytotoxicity of cachectin/TNF-sensitive L929 cells, to stimulate the blastogenesis of endotoxin-resistant C3H/HeJ thymocytes, or to induce the production of cachectin/TNF by primary thioglycollate-elicited mouse macrophage cells. These latter characteristics all absent from the present inflammatory cytokine are exhibited by the known factors cachectin/TNF and interleukin-1 (IL-1), and thereby distinguish the present inflammatory cytokine therefrom.

The most significant affirmative activities exhibited by the present inflammatory cytokine appear to be the ability to bind to heparin and the ability to induce localized inflammation characterized by polymorphonuclear (PMN) cell infiltration. Accordingly, while the exact role that the present isolate plays in the cascade of reactions to host invasion is as yet undefined, its participation in the elicitation of certain of the activities and conditions associated with mobilization against host invasion is clear. Accordingly, the inflammatory cytokine possesses the potential for use as a diagnostic tool to identify and perhaps differentiate

between various stimuli whether invasive or idiopathic, by the activation of the present inflammatory cytokine that such stimuli may promote.

- 5 The present inflammatory cytokine was initially identified and characterized and found to contain a single chain, 6 kilodalton protein on sodium dodecyl sulfate (SDS-PAGE) which migrates on gel filtration as a monomer or dimer. Partial N-terminal amino acid sequence
10 data as depicted in FIGURE 2 revealed that MIP-2 is a member of a family of cytokines, the archetype of which is platelet factor 4 (PF₄).

As set out above, the present inflammatory cytokine may
15 be prepared by the stimulation of macrophage cells with a material that accompanies an invasive stimulus. In particular, a sample of macrophage cells which may be derived from a variety of sources may be incubated with a stimulator material such as endotoxin or trypanosomes, to
20 produce the mediator substance disclosed in U.S. Patent No. 4,603,106. Such incubation may take place for a period of time of up to twenty hours, and exact time limits will vary with the particular cells selected for incubation.

25 Further properties of the present inflammatory cytokine include its inability to induce fever in rabbits, or to induce superoxide formation or a respiratory burst in human neutrophils in vitro.

30 Following such incubation, the medium may be appropriately treated as by centrifuging, to recover a supernatant containing the crude mediator substance. The mediator substance may then be further treated as by
35 filtration or precipitation. Thereafter, the crude mediator substance may be subjected to a series of known isolation techniques, whereupon the inflammatory cytokine may be recovered. The present invention naturally

contemplates alternate means for preparation of the inflammatory cytokine, including where applicable known genetic replicative techniques, and the invention is accordingly intended to cover such synthetic preparations
5 within its scope.

As noted above, the present invention also includes a purified protein having the above-noted activities and characteristics, that displays the NH₂-terminal partial
10 amino acid consensus sequence set forth in FIGURE 6, as determined in mice. The cDNA for MIP-2 has been cloned and, as set forth in FIGURE 7, predicts a mature protein of 74 amino acids in length with a molecular weight of 7908 and a translated molecular weight of 10,622.52 for
15 the precursor peptide.

Accordingly, the present invention also includes the identification of the purified peptide comprising the present cytokine that exhibits the above noted activities
20 and characteristics, and that displays the mature amino acid sequence set forth below and in FIGURE 7, as determined in mice.

GLY ALA VAL VAL ALA SER GLU LEU ARG CYS GLN CYS LEU LYS
25 THR LEU PRO ARG VAL ASP PHE LYS ASN ILE GLN SER LEU SER
VAL THR PRO PRO GLY PRO HIS CYS ALA GLN THR GLU VAL ILE
ALA THR LEU LYS GLY GLY GLN LYS VAL CYS LEU ASP PRO GLU
ALA PRO LEU VAL GLN LYS ILE ILE GLN LYS ILE LEU ASN LYS
GLY LYS ALA ASN

30

As stated earlier, the foregoing sequence bears no striking similarity to any of the known factors and accordingly establishes that the present inflammatory cytokine is distinguishable therefrom. The isolation of
35 the above cDNA amino acid sequence facilitates the reproduction of this cytokine by recombinant genetic techniques as discussed in detail hereinafter. Thus, the invention provides the DNA sequence encoding the present

inflammatory cytokine or analogs thereof, which may be used to construct vectors for expression in host systems by recombinant DNA techniques.

- 5 The invention further includes a method for detecting idiopathic or invasive stimuli on the basis of their ability to elicit the activities affected by the present inflammatory cytokine. In particular, invasive stimuli could be identified and detected by their ability to
10 induce a material which is able to bind to heparin and to induce localized inflammation with neutrophil infiltration and chemotacticity. In this method, macrophage cells derived for example, from the RAW 264.7 cell line could be treated with/exposed to a number of
15 known stimulator materials such as endotoxin, trypanosomes or the like, as a control, while parallel cellular samples could be treated with or exposed to an extract of material from the presumed situs of the infective stimulus. All samples could thereafter be
20 incubated in accordance with the methods described above, and thereafter subjected to the sequence of separation techniques also defined, whereupon testing of the resulting isolates derived from the control and unknown samples could be compared to determine whether the
25 inflammatory cytokine, if any, developed is identical or even similar.

In similar fashion, an assay system for screening of potential drugs effective to counteract the inflammatory
30 cytokine may be prepared. In one instance, the test drug could be administered to a stimulated macrophage sample to determine its effect upon the production of the inflammatory cytokine. In an alternate procedure, the inflammatory cytokine may be introduced into a cellular
35 test system in which the cytokine is known to be active, and the prospective drug may also be introduced to the same cell culture and the culture may thereafter be examined to observe any changes in the activity of the

inflammatory cytokine in comparison with the addition of the prospective drug alone, or the effect of added quantities of the known inflammatory cytokine.

- 5 The present invention also relates to a method for detecting the presence of stimulated, spontaneous, or idiopathic pathological states in mammals, by measuring the activity and presence of the inflammatory cytokine of the present invention. More particularly the activity
10 of the inflammatory cytokine may be followed directly by the assay techniques discussed later on, through the use of an appropriately labeled quantity of the cytokine. Alternately, the cytokine can be used to raise binding partners or antibodies that could in turn, be labeled and
15 introduced into a medium such as serum, to test for the presence of inflammatory cytokine therein, and to thereby assess the state of the host from which the medium was drawn.
- 20 Thus, both the inflammatory cytokine and any antibodies that may be raised thereto, are capable of use in connection with various diagnostic techniques, including immunoassays, such as a radioimmunoassay, using for example, an antibody to the inflammatory cytokine that
25 has been labeled by either radioactive addition, reduction with sodium borohydride, or radioiodination.

In an immunoassay, a control quantity of the inflammatory cytokine, its antibody, or the like may be prepared and
30 labeled with an enzyme, a specific binding partner and/or a radioactive element, and may then be introduced into a blood sample of a mammal believed to be undergoing invasion. After the labeled material or its binding partner(s) has had an opportunity to react with sites
35 within the sample, the resulting mass may be examined by known techniques, which may vary with the nature of the label attached.

In the instance where a radioactive label, such as the isotopes ^{14}C , ^{131}I , ^3H , ^{125}I and ^{35}S are used, known currently available counting procedures may be utilized. In the instance where the label is an enzyme, detection may be accomplished by any of the presently utilized colorimetric, spectrophotometric, fluorospectrophotometric or gasometric techniques known in the art. The present invention includes an assay system which may be prepared in the form of a test kit for the quantitative analysis of the extent of the presence of the inflammatory cytokine. The system or test kit may comprise a labeled component prepared by one of the radioactive and/or enzymatic techniques discussed herein, coupling a label to the inflammatory cytokine; and one or more additional immunochemical reagents, at least one of which is a free or immobilized ligand, capable either of binding with the labeled component, its binding partner, one of the components to be determined or their binding partner(s).

20

In a further embodiment, the present invention relates to certain therapeutic methods which would be based upon the activity of the inflammatory cytokine, antibodies to the inflammatory cytokine, or upon agents or other drugs determined to possess the same or an antagonistic activity. A first therapeutic method is associated with the prevention of the manifestations of the activities of the inflammatory cytokine in mammals, such as inflammation and fever, and comprises administering either an antibody to the cytokine, an agent capable of modulating the production and/or activity of the cytokine, or an agent not an antibody to the cytokine that is capable of acting as an antagonist to the cytokine, either individually or in mixture with each other in an amount effective to prevent the development of those conditions in the host.

More specifically, the therapeutic method generally referred to herein could include the method for the treatment of inflammation and fever by the administration of pharmaceutical compositions that may comprise effective quantities of antibodies to the inflammatory cytokine, or other equally effective drugs developed for instance by a drug screening assay prepared and used in accordance with a further aspect of the present invention.

10

A variant embodiment of this therapeutic method could include initially detecting the presence and activity of the inflammatory cytokine and thereafter administering the appropriate pharmaceutical composition.

15

A second therapeutic method seeks to take advantage of the inflammatory activity of the cytokine and in particular, its ability to cause the movement and mobilization of neutrophils in response to invasive stimuli such as infection. Accordingly, the inflammatory cytokine may be prepared in a suitable formulation for administration to the situs of infection which for example, may develop where tissue trauma has occurred. In such instance, the inflammatory cytokine may be prepared in a sterile solution and delivered to the trauma or wound as part of an irrigation fluid or by direct dosage such as, in a pharmaceutical composition, the latter course of administration contemplating topical and parenteral routes. Naturally, the inflammatory cytokine may be used to raise equally effective agents or drugs by known methods that may then be formulated into pharmaceutical compositions suitable for administration in the same manner and for the same purpose as for the inflammatory cytokine itself.

35

Accordingly, it is a principal object of the present invention to provide an inflammatory cytokine in purified form that exhibits certain characteristics and activities

associated with the host response to invasive stimuli in mammals.

It is a further object of the present invention to
5 provide methods for the preparation of the inflammatory cytokine, including recombinant means.

It is a further object of the present invention to
provide a method for detecting the presence of the
10 inflammatory cytokine in mammals in which invasive, spontaneous, or idiopathic pathological states such as infection are suspected to be present.

It is a further object of the present invention to
15 provide a method and associated assay system for screening substances such as drugs, agents and the like, potentially effective in either mimicking the activity or combating the adverse affects of the inflammatory cytokine in mammals.

20 It is a still further object of the present invention to provide a method for the treatment of mammals to control the amount or activity of the inflammatory cytokine, so as to alter the adverse consequences of such presence or
25 activity.

It is a still further object of the present invention to provide a method for the treatment of mammals to promote the amount or activity of the inflammatory cytokine, so
30 as to treat or avert the adverse consequences of invasive, spontaneous or idiopathic pathological states.

It is a still further object of the present invention to provide pharmaceutical compositions for use in
35 therapeutic methods which comprise or are based upon the inflammatory cytokine or its binding partner(s), or upon agents or drugs that control the production, or that

mimic or antagonize the activities of the inflammatory cytokine.

Other objects and advantages will become apparent to those skilled in the art from a review of the ensuing description which proceeds with reference to the following illustrative drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

10

FIGURE 1 is an electrophoretic gel depiction of the purification of MIP-2. The final positions of the molecular weight markers (in kilodaltons) are shown on the left along with the positions of cachectin/TNF and MIP-1 in this 10-18% NaDodSO₄-PAGE system. The four lanes show successive stages of purification of MIP-2: Lane 1 - concentrated and diafiltrated crude supernatant from RAW 264.7 cells; Lane 2 - effluent from Mono Q (anion exchange) column chromatography of RAW 264.7 supernatant; Lane 3 - pooled peak fractions after purification on heparin-Sepharose; Lane 4 - pure MIP-2 fractions after purification on Superose 12 (gel filtration).

FIGURE 2 depicts the partial NH₂-terminal amino acid sequences of MIP-2 and other members of the platelet factor 4 family. Sequences were obtained from the literature and aligned via a conserved cysteine residue. PBP (platelet basic protein) is the precursor for β -thromboglobulin and CTAP III. Amino acids enclosed in boxes are conserved between the various members of the platelet factor 4 family. Lower case prefixes refer to species: m = murine, h = human, b = bovine, r = rat, c = chicken, ham = hamster.

FIGURE 3 is a table showing a comparison of the percent sequence identity over the region corresponding to the partial NH₂-terminal amino acid sequence obtained for MIP-2. Sequences were compared using the FASTP program.

Comparisons are only for the portion of each sequence corresponding to that available for MIP-2 as aligned in Fig. 2. Ins. = Insignificant.

- 5 FIGURE 4 depicts an immunoblot analysis characterizing the relationship between MIP-2 and other members of the platelet factor 4 family. (A) Silver stain of duplicate of gel used for immunoblot of MIP-2. (B) Immunoblot of MIP-2: Lane 1 - purified MIP-2; Lane 2 - supernatant
10 from endotoxin-stimulated RAW 264.7 cells; Lane 3 - supernatant from non-stimulated thioglycollate-elicited mouse peritoneal macrophages; Lane 4 - supernatant from endotoxin-stimulated, thioglycollate-elicited mouse peritoneal macrophages; Lane 5 - purified NAP-1 protein;
15 Lane 6 - supernatant from COS cells transfected with plasmid alone; Lane 7 - supernatant from COS cells transfected with plasmid containing the human gro gene; Lane 8 - supernatant from COS cells transfected with plasmid containing the hamster gro gene. Lanes 7 and 8
20 are reversed in the immunoblot (4b).

- FIGURE 5 is a graphical depiction of human polymorphonuclear chemotaxis and chemokinesis in response to MIP-2. Chemotaxis (darkened bars) was measured by
25 introducing MIP-2 into the lower well of the chamber only. Chemokinesis (lightened bars) was measured by introducing the same concentration of MIP-2 into the upper and lower chambers. fMet-Leu-Phe (fMLP) was used at a concentration of 10^{-8} M.

30

FIGURE 6 is a depiction of the partial N-terminal sequence of the inflammatory cytokine of the present invention.

- 35 FIGURE 7 depicts the complete nucleotide sequence of a cDNA clone for MIP-2. The predicted translated molecular weight of the precursor peptide is 10,622.52. The mature

peptide sequence, starting at position one, is 74 amino acids in length.

DETAILED DESCRIPTION

5

In accordance with the present invention there may be employed conventional molecular biology, microbiology, and recombinant DNA techniques within the skill of the art. Such techniques are explained fully in the literature. See, e.g., Maniatis, Fritsch & Sambrook, "Molecular Cloning: A Laboratory Manual" (1982); "DNA Cloning: A Practical Approach," Volumes I and II (D.N. Glover ed. 1985); "Oligonucleotide Synthesis" (M.J. Gait ed. 1984); "Nucleic Acid Hybridization" (B.D. Hames & S.J. Higgins eds. 1985); "Transcription And Translation" (B.D. Hames & S.J. Higgins eds. 1984); "Animal Cell Culture" (R.I. Freshney ed. 1986); "Immobilized Cells And Enzymes" (IRL Press, 1986); B. Perbal, "A Practical Guide To Molecular Cloning" (1984).

20

Therefore if appearing herein, the following terms shall have the definitions set out below.

The term "stimulus" and its plural as used herein are intended to apply to invasive events such as infection, as well as conditions caused by wounding, and to idiopathic or spontaneous states that may for example, originate from cellular or metabolic derangements or other causes.

30

The terms "inflammatory cytokine", "macrophage inflammatory protein 2" and "MIP-2" as used throughout the present application and claims refer to protein material having the partial N-terminal sequence data presented in FIGURES 2 and 6, the mature peptide sequence presented in FIGURE 7, and the profile of activities set forth herein and in the Claims. Accordingly, proteins having similar sequences to those set forth herein but

displaying substantially equivalent or altered activity are likewise contemplated. These modifications may be deliberate, for example, such as modifications obtained through site-directed mutagenesis, or may be accidental, such as those obtained through mutations in hosts that are MIP-2 producers. Also, the terms "inflammatory cytokine", "macrophage inflammatory protein 2" and "MIP-2" are intended to include within their scope the proteins specifically recited herein as well as all substantially homologous analogs and allelic variations.

A "replicon" is any genetic element (e.g., plasmid, chromosome, virus) that functions as an autonomous unit of DNA replication in vivo; i.e., capable of replication under its own control.

A "vector" is a replicon, such as plasmid, phage or cosmid, to which another DNA segment may be attached so as to bring about the replication of the attached segment.

A "DNA molecule" refers to the polymeric form of deoxyribonucleotides (adenine, guanine, thymine, or cytosine) in its either single stranded form, or a double-stranded helix. This term refers only to the primary and secondary structure of the molecule, and does not limit it to any particular tertiary forms. Thus, this term includes double-stranded DNA found, inter alia, in linear DNA molecules (e.g., restriction fragments), viruses, plasmids, and chromosomes. In discussing the structure of particular double-stranded DNA molecules, sequences may be described herein according to the normal convention of giving only the sequence in the 5' to 3' direction along the nontranscribed strand of DNA (i.e., the strand having a sequence homologous to the mRNA).

A DNA "coding sequence" is a double-stranded DNA sequence which is transcribed and translated into a polypeptide in

vivo when placed under the control of appropriate regulatory sequences. The boundaries of the coding sequence are determined by a start codon at the 5' (amino) terminus and a translation stop codon at the 3' (carboxyl) terminus. A coding sequence can include, but is not limited to, prokaryotic sequences, cDNA from eukaryotic mRNA, genomic DNA sequences from eukaryotic (e.g., mammalian) DNA, and even synthetic DNA sequences. A polyadenylation signal and transcription termination sequence will usually be located 3' to the coding sequence.

Transcriptional and translational control sequences are DNA regulatory sequences, such as promoters, enhancers, polyadenylation signals, terminators, and the like, that provide for the expression of a coding sequence in a host cell.

A "promoter sequence" is a DNA regulatory region capable of binding RNA polymerase in a cell and initiating transcription of a downstream (3' direction) coding sequence. For purposes of defining the present invention, the promoter sequence is bounded at its 3' terminus by the transcription initiation site and extends upstream (5' direction) to include the minimum number of bases or elements necessary to initiate transcription at levels detectable above background. Within the promoter sequence will be found a transcription initiation site (conveniently defined by mapping with nuclease S1), as well as protein binding domains (consensus sequences) responsible for the binding of RNA polymerase. Eukaryotic promoters will often, but not always, contain "TATA" boxes and "CAT" boxes. Prokaryotic promoters contain Shine-Dalgarno sequences in addition to the -10 and -35 consensus sequences.

A coding sequence is "under the control" of transcriptional and translational control sequences in a

cell when RNA polymerase transcribes the coding sequence into mRNA, which is then translated into the protein encoded by the coding sequence.

5 A "signal sequence" can be included before the coding sequence. This sequence encodes a signal peptide, N-terminal to the polypeptide, that communicates to the host cell to direct the polypeptide to the cell surface or secrete the polypeptide into the media, and this
10 signal peptide is clipped off by the host cell before the protein leaves the cell. Signal sequences can be found associated with a variety of proteins native to prokaryotes and eukaryotes. For instance, alpha-factor, a native yeast protein, is secreted from yeast, and its
15 signal sequence can be attached to heterologous proteins to be secreted into the media (See U.S. Patent 4,546,082, EPO 0 116 201, publication date 12 January 1983; U.S. Patent Application Ser. No. 522,909, filed 12 August 1983). Further, the alpha-factor leader and its analogs
20 have been found to secrete heterologous proteins from a variety of yeast, such as *Saccharomyces* and *Kluyveromyces*, (EPO 88312306.9 filed 23 December 1988; U.S. Patent Application Ser. No. 139,682, filed 30 December 1987, and EPO Pub. No. 0 301 669, publication
25 date 1 February 1989).

A cell has been "transformed" by exogenous or heterologous DNA when such DNA has been introduced inside the cell. The transforming DNA may or may not be
30 integrated (covalently linked) into chromosomal DNA making up the genome of the cell. In prokaryotes, yeast, and mammalian cells for example, the transforming DNA may be maintained on an episomal element such as a plasmid. With respect to eukaryotic cells, a stably transformed
35 cell is one in which the transforming DNA has become integrated into a chromosome so that it is inherited by daughter cells through chromosome replication. This stability is demonstrated by the ability of the

eukaryotic cell to establish cell lines or clones comprised of a population of daughter cells containing the transforming DNA. A "clone" is a population of cells derived from a single cell or common ancestor by mitosis.

- 5 A "cell line" is a clone of a primary cell that is capable of stable growth in vitro for many generations.

- Two DNA sequences are "substantially homologous" when at least about 75% (preferably at least about 80%, and most preferably at least about 90 or 95%) of the nucleotides match over the defined length of the DNA sequences. Sequences that are substantially homologous can be identified by comparing the sequences using standard software available in sequence data banks, or in a
- 10 Southern hybridization experiment under, for example, stringent conditions as defined for that particular system. Defining appropriate hybridization conditions is within the skill of the art. See, e.g., Maniatis et al., supra; DNA Cloning, Vols. I & II, supra; Nucleic Acid
- 15 Hybridization, supra.

- A "heterologous" region of the DNA construct is an identifiable segment of DNA within a larger DNA molecule that is not found in association with the larger molecule
- 25 in nature. Thus, when the heterologous region encodes a mammalian gene, the gene will usually be flanked by DNA that does not flank the mammalian genomic DNA in the genome of the source organism. Another example of a heterologous coding sequence is a construct where the
- 30 coding sequence itself is not found in nature (e.g., a cDNA where the genomic coding sequence contains introns, or synthetic sequences having codons different than the native gene). Allelic variations or naturally-occurring mutational events do not give rise to a heterologous
- 35 region of DNA as defined herein.

A composition comprising "A" (where "A" is a single protein, DNA molecule, vector, etc.) is substantially

free of "B" (where "B" comprises one or more
contaminating proteins, DNA molecules, vectors, etc.)
when at least about 75% by weight of the proteins, DNA,
vectors (depending on the category of species to which A
5 and B belong) in the composition is "A". Preferably, "A"
comprises at least about 90% by weight of the A+B species
in the composition, most preferably at least about 99% by
weight. It is also preferred that a composition, which
is substantially free of contamination, contain only a
10 single molecular weight species having the activity or
characteristic of the species of interest.

An "antibody" is any immunoglobulin, including antibodies
and fragments thereof, that binds a specific epitope.
15 The term encompasses, inter alia, polyclonal, monoclonal,
and chimeric antibodies, the last mentioned described in
further detail in U.S. Patent Nos. 4,816,397 and
4,816,567.

20 Intron-free DNA provided by the present invention is
novel, since it is believed that the naturally-occurring
human genes contain introns. Hence, the term "intron-
free" excludes the DNA sequences which naturally occur in
the chromosomes of human or bovine cells. The present
25 invention also encompasses the intron-free cDNA sequences
derivable from the DNA sequences disclosed herein.

In its primary aspect, the present invention concerns the
isolation and identification of a newly discovered
30 particular factor hereinafter referred to as the
inflammatory cytokine, macrophage inflammatory protein 2
or MIP-2, that has been found to be present in
macrophages or macrophage cell lines that are stimulated
by materials referred to herein as stimulator materials,
35 that characteristically accompany an invasive stimulus,
such as bacteria, virus, certain tumors, protozoa and
other toxins such as endotoxin, or an idiopathic state.
As with the mediator substance disclosed in U.S. Patent

No. 4,603,106, the present inflammatory cytokine, which has been determined to be a component of the former mediator substance, appears to be capable of causing certain conditions such as inflammation to develop in the
5 tissues of a mammal, which reflect the reaction of a mammal in a stimulated or spontaneous pathological state.

In particular, the inflammatory cytokine appears to be capable of inducing localized inflammation when
10 administered subcutaneously which inflammation is characterized by polymorphonuclear cell infiltration. Also, the cytokine is a potent chemotactic agent for human polymorphonuclear leukocytes while inducing little or no chemokinesis or an oxidative burst in human
15 neutrophils in vitro, which conditions reflect the influence of a cytokine involved in mobilization by the mammalian host against an invasive stimulus. While the full and exact role played by the present inflammatory cytokine is unclear, it is theorized that the cytokine in
20 conjunction with other factors previously identified and those yet to be elucidated, functions as part of a communication system between the immune system of the host and other body tissues and organs.

25 The ability of the present inflammatory cytokine to bind to heparin gave rise to the consideration that the cytokine might correspond to certain heparin-binding growth factors such as FGF or PDGF. However, data indicating that the inflammatory cytokine is not
30 mitogenic for smooth muscle cells suggests a distinction from these known growth factors. Accordingly, what is certain at this time, is that the cytokine of the present invention participates in the development of the inflammatory response that is known to be a part of host
35 responses such as to invasion.

The present inflammatory cytokine has been confirmed to comprise a protein that possesses a molecular mass of

approximately 6,000 daltons on NaDodSO₄-PAGE and fractionates from a gel filtration column with an apparent molecular mass of approximately 10,000 daltons. The cDNA for MIP-2 has been cloned and predicts a mature
5 protein of 74 amino acids in length with a predicted molecular weight of 7,908. In contrast to MIP-1 and cachectin/TNF, MIP-2 is cationic and does not bind to an anion exchange column equilibrated at pH 8.0. In
10 addition, the determination of the N-terminal partial amino acid sequence and the full sequence of the mature protein confirms that the specific protein structure of the present inflammatory cytokine differs from that of other known factors. Accordingly, both structural and functional distinctions between the present inflammatory
15 cytokine and the known factors of the prior art exists as is confirmed by the data set forth in Example 1.

More particularly, the inflammatory cytokine of the present invention possesses certain other characteristics
20 in conjunction with those outlined above, in that it is capable of binding to heparin at high salt concentrations, e.g. approximately 0.7 M, and demonstrates colony stimulating factor activity. The cytokine is also distinctive in those activities that it
25 lacks, such as its inability to suppress the anabolic enzyme lipoprotein lipase (LPL), to cause the cytotoxicity of cachectin/TNF-sensitive L929 cells, stimulate the blastogenesis of endotoxin-resistant C3H/HeJ thymocytes or to induce the production of
30 cachectin/TNF by primary thioglycollate-elicited mouse macrophage cells. All of these latter activities are exhibited by the other known macrophage-derived mediator factors whose general characteristics and activities have identified them as participants in the host response to
35 invasion. In addition, the present inflammatory cytokine is distinguishable from other factors such as MIP-1 by its inability either to induce fever in rabbits, or to

induce superoxide formation or respiratory burst in human neutrophils.

The activity profile presented above accordingly
5 distinguishes the present inflammatory cytokine from those known factors and confirms in conjunction with the amino acid sequencing data presented herein, that the present inflammatory cytokine is indeed distinct from the other macrophage-derived mediator factors.

10 As stated earlier, the primary amino acid sequence shown in FIGURE 2 and the full sequence shown in FIGURE 7 are only illustrative, and similar sequences may result in proteins which have substantially equivalent or enhanced
15 activity. These modifications may be deliberate, for example, such as modifications obtained through site-directed mutagenesis, or may be accidental, such as those obtained through mutations in hosts which are MIP-2 producers. All of those modifications are included in
20 the present invention, as long as the MIP-2 activity, as defined above, is retained. Accordingly, the definition of MIP-2 as stated herein and elsewhere in the specification includes proteins having an amino acid sequence substantially equivalent to that in FIGURES 2
25 and 7 as well as other substantially homologous analogs and allelic variations within its scope.

The preparation of the inflammatory cytokine was discussed in brief earlier herein, and is confirmed to be
30 capable of proceeding in the instance of the native material by the initiation of the incubation of a variety of cells with stimulator materials from invasive stimuli. In particular, the cell line RAW 264.7 may be utilized to initiate the production of the material from which the
35 inflammatory cytokine may be isolated. The murine macrophage cell line RAW 264.7 has facilitated the isolation of the inflammatory cytokine in quantities large enough to permit analysis and purification.

Naturally, other cell lines or other sources for the development of either the material from which the inflammatory cytokine is thereafter isolated, or the inflammatory cytokine itself, are contemplated herein and
5 the present invention is accordingly not limited.

As discussed earlier herein, alternate means such as by genetic replication which may be conducted in accordance with many of the generic principles of recombinant
10 technology that are well known in the art, are contemplated herein in accordance with the present invention.

Accordingly, MIP-2 nucleic acid sequences may be obtained
15 from the deduced amino acid sequence by recombinant DNA methods, such as by screening reverse transcripts of mRNA, or by screening genomic libraries from any cell. The DNA may also be obtained by synthesizing the DNA using commonly available techniques and DNA synthesizing
20 apparatus. Synthesis may be advantageous because unique restriction sites may be introduced at the time of preparing the DNA, thereby facilitating the use of the gene in vectors containing restriction sites not otherwise present in the native source. Furthermore, any
25 desired site modification in the DNA may be introduced by synthesis, without the need to further modify the DNA by mutagenesis.

A general procedure for isolating DNA encoding the
30 present inflammatory cytokine from human, murine, or other sources is to construct a cDNA library from mRNA isolated from the appropriate cells or tissue; and screen with labeled DNA probes encoding portions of the polypeptide chain in order to detect clones in the cDNA
35 library that contain homologous sequences.

Alternatively, one may isolate the DNA by polymerase chain reaction (PCR) amplification of the cDNA (from mRNA) and subclone and screen with labeled DNA probes;

and then analyze the clones by restriction enzyme analysis and nucleic acid sequencing so as to identify full-length clones. If full-length clones are not present in the library, appropriate fragments from the various clones may be recovered and ligated at restriction sites common to the clones to assemble a clone encoding a full-length molecule.

A suitable and preferred DNA probe is set forth in the accompanying examples. Any sequences missing from the 5' end of the MIP-2 cDNA may be obtained by the 3' extension of the synthetic oligonucleotides complementary to MIP-2 sequences using mRNA as a template (so-called primer extension), or homologous sequences may be supplied from known cDNAs derived from murine sequences as shown in FIGURE 7. This will be more particularly described in Example 2; however, it is realized that once being provided with intron-free DNA encoding murine MIP-2 and its leader sequences as described herein, one of ordinary skill in the art would recognize that other precisely hybridizing probes may be prepared from the described sequences in order to readily obtain the desired gene.

Vectors are used to simplify manipulation of the DNA which encodes the MIP-2 polypeptide, either for preparation of large quantities of DNA for further processing (cloning vectors) or for expression of the MIP-2 polypeptide (expression vectors). Vectors comprise plasmids, viruses (including phage), and integratable DNA fragments, i.e., fragments that are integratable into the host genome by recombination. Cloning vectors need not contain expression control sequences. However, control sequences are needed in an expression vector, and these control sequences include transcriptional and translational control sequences such as a transcriptional promoter, an optional operator sequence to control transcription, a sequence encoding suitable ribosome binding sites (for prokaryotic expression), and sequences

which control termination of transcription and translation. The expression vector should preferably include a selection gene to facilitate the stable expression of MIP-2 and/or to identify transformants.

- 5 However, the selection gene for maintaining expression can be supplied by a separate vector in cotransformation systems using eukaryotic host cells.

For expression suitable vectors generally will contain
10 replicon (origins of replication, for use in non-integrative vectors) and control sequences which are derived from species compatible with the intended expression host. By the term "replicable" vector as used herein, it is intended to encompass vectors containing
15 such replicons as well as vectors which are replicated by integration into the host genome. Cells are then transformed or transfected with vectors containing MIP-2 encoding DNA and are now identified as transformed host cells. MIP-2 expressed from these transformed hosts will
20 be either deposited intracellularly or secreted into the periplasmic space or the culture supernatant, depending upon the host cell selected and the presence of suitable processing signals in the expressed peptide, e.g. homologous or heterologous signal sequences.

25 Suitable host cells for expression can be prokaryotic or eukaryotic cells. Prokaryotes include Gram negative or Gram positive organisms, for example E. coli or Bacillus subtilis. Eukaryotic cells include yeast, baculovirus or
30 higher eukaryotic cells such as established cell lines of mammalian origin.

Expression vectors for host cells ordinarily include an origin of replication (unless it is an integrating
35 vector), a promoter located upstream from the MIP-2 coding sequence, together with a ribosome binding site, a polyadenylation site, and a transcriptional termination sequence. Those of ordinary skill will appreciate that

certain of these sequences are not required for expression in certain hosts. A non-integrating expression vector for use with microbes need only contain an origin of replication recognized by the host, a
5 promoter which will function in the host and a selection gene.

An expression vector is constructed according to the present invention so that the MIP coding sequence is
10 located in the vector with the appropriate regulatory sequences, the positioning and orientation of the coding sequence with respect to the control sequences being such that the coding sequence is transcribed and translated under the "control" of the control sequences (i.e., RNA
15 polymerase which binds to the DNA molecule at the control sequences transcribes the coding sequence). The control sequences may be ligated to the coding sequence prior to insertion into a vector, such as the cloning vectors described above. Alternatively, the coding sequence can
20 be cloned directly into an expression vector which already contains the control sequences and an appropriate restriction site. For expression of MIP-2 in prokaryotes and yeast, the control sequences will necessarily be heterologous to the coding sequence. If the host cell is
25 a prokaryote, it is also necessary that the coding sequence be free of introns (e.g., cDNA). If the selected host cell is a mammalian cell, the control sequences can be heterologous or homologous to the MIP coding sequence, and the coding sequence can either be
30 genomic DNA containing introns or cDNA.

Expression vectors must contain a promoter which is recognized by the host organism. Promoters commonly known and available which are used in prokaryotic
35 recombinant DNA expression include the β -lactamase (penicillinase) and lactose promoter systems, a tryptophan (trp) promoter system and the tac promoter.

While these are commonly used, other known microbial promoters are suitable.

In addition to prokaryotes, eukaryotic cells such as yeast may be transformed with MIP-2 encoding vectors. Yeast vectors generally will contain an origin of replication or an autonomously replicating sequence (ARS), (if non-integrating) a promoter, DNA encoding MIP-2, sequences for polyadenylation and transcription termination, and a selection gene.

Of particular interest to the present invention are yeast species within the genera *Pichia*, *Kluyveromyces*, *Saccharomyces*, *Schizosaccharomyces* and *Candida*. Of particular interest are the *Saccharomyces* species *S. cerevisiae*, *S. carlsbergensis*, *S. diastaticus*, *S. douglasii*, *S. kluyveri*, *S. norbensis*, and *S. oviformis*. Species of particular interest in the genus *Kluyveromyces* include *K. lactis*, and in the genus *Pichia* include *P. pastoris*. Since the classification of yeast may change in the future, for the purposes of this invention, yeast shall be defined as described in Biology and Activities of Yeast (F.A. Skinner, S.M. Passmore and R.R. Davenport, eds. 1980) (SOC. APP. BACTERIOL. SYMP. SERIES NO. 9). In addition to the foregoing, those of ordinary skill in the art are presumably familiar with the biology of yeast and the manipulation of yeast genetics. See, e.g. Biochemistry and Genetics of Yeast (M. Bacila, B.L. Horecker and A.O.M. Stoppani eds. 1978); The Yeasts (A.H. Rose and J.S. Harrison eds., 2nd ed., 1987); The Molecular Biology of The Yeast Saccharomyces (Strathern et al. eds. 1981). The disclosures of the foregoing references are incorporated herein by reference.

Suitable promoter sequences in yeast vectors include the promoters for the glycolytic enzymes such as enolase, 3-phosphoglycerate kinase, glyceraldehyde-3-phosphate dehydrogenase, hexokinase, pyruvate decarboxylase,

phosphofructokinase, glucose-6-phosphate isomerase, 3-phosphoglycerate mutase, pyruvate kinase, triosephosphate isomerase, phosphoglucose isomerase, and glucokinase.

- 5 Other yeast promoters, which have the additional advantage of transcription controlled by growth conditions are the promoter regions for alcohol dehydrogenase 1 or 2, isocytochrome C, acid phosphatase, as well as enzymes responsible for maltose and galactose
10 utilization.

Higher eukaryotic cell cultures may be used, whether from vertebrate or invertebrate cells, including insects, and the procedures of propagation thereof are known. See,
15 for example, Tissue Culture, Academic Press, Kruse and Patterson, editors (1973).

Suitable host cells for expressing MIP-2 in higher eukaryotes include: monkey kidney CVI line transformed by
20 SV40 (COS-7, ATCC CRL 1651); baby hamster kidney cells (BHK, ATCC CRL 10); Chinese hamster ovary-cells-DHFR (described by Urlaub and Chasin, PNAS (USA) 77: 4216 (1980)); mouse Sertoli cells (TM4, Mather, J.P., Biol. Reprod. 23: 243-251 (1980)); monkey kidney cells (CVI
25 ATCC CCL 70); African green monkey kidney cells (VERO-76, ATCC CRL-1587); human cervical carcinoma cells (HELA, ATCC CCL 2); canine kidney cells (MDCK, ATCC CCL 34); buffalo rat liver cells (BRL 3A, ATCC CRL 1442); human lung cells (W138, ATCC CCL 75); human liver cells (Hep
30 G2, HB 8065); mouse mammary tumor (MMT 060652, ATCC CCL 51); rat hepatoma cells (HTC, M1, 54, Baumann, M., et al., J. Cell Biol. 85: 1-8 (1980)) and TRI cells (Mather, J.P., et al., Annals N.Y. Acad. Sci. 383: 44-68 (1982)). Commonly used promoters are derived from polyoma,
35 adenovirus 2, and simian virus 40 (SV40). It will be appreciated that when expressed in eukaryotic rather than prokaryotic cells, the recombinant MIP-2 may have higher molecular weight due to glycosylation. It is therefore

intended that partially or completely glycosylated forms of MIP-2 having molecular weights greater than the predicted molecular weight of 7,908 are within the scope of this invention as well as its unglycosylated forms.

5

A number of prokaryotic expression vectors are known in the art. See, e.g., U.S. Patent Nos. 4,440,859; 4,436,815; 4,431,740; 4,431,739; 4,428,941; 4,425,437; 4,418,149; 4,411,994; 4,366,246; 4,342,832; see also U.K. Pub. Nos. GB 2,121,054; GB 2,008,123; GB 2,007,675; and European Pub. No. 103,395. Preferred prokaryotic expression systems are in E. coli.

Other preferred expression vectors are those for use in eukaryotic systems. An exemplary eukaryotic expression system is that employing vaccinia virus, which is well-known in the art. See, e.g., Macket et al. (1984) J. Virol. 49:857; "DNA Cloning," Vol. II, pp. 191-211, supra; PCT Pub. No. WO 86/07593. Yeast expression vectors are known in the art. See, e.g., U.S. Patent Nos. 4,446,235; 4,443,539; 4,430,428; see also European Pub. Nos. 103,409; 100,561; 96,491. Another preferred expression system is vector pHS1, which transforms Chinese hamster ovary cells. See PCT Pub.

No. WO 87/02062. Mammalian tissue may be cotransformed with DNA encoding a selectable marker such as dihydrofolate reductase (DHFR) or thymidine kinase and DNA encoding MIP-2.

If wild type DHFR gene is employed, it is preferable to select a host cell which is deficient in DHFR, thus permitting the use of the DHFR coding sequence as marker for successful transfection in hgt medium, which lacks hypoxanthine, glycine, and thymidine. An appropriate host cell in this case is the Chinese hamster ovary (CHO) cell line deficient in DHFR activity, prepared and propagated as described by Urlaub and Chasin, 1980, Proc. Nat. Acad. Sci. (USA) 77: 4216. Expression vectors

derived from baculovirus for use in insect cells are known and available in the art. See Lucklow and Summers, Biotechnology, 6, p. 47-55.

- 5 Depending on the expression system and host selected, MIP-2 is produced by growing host cells transformed by an exogenous or heterologous DNA construct, such as an expression vector described above and in Example 2 herein, under conditions whereby the MIP-2 protein is
10 expressed. The MIP-2 is then isolated from the host cells and purified. If the expression system secretes MIP-2 into growth media, the protein can be purified directly from cell-free media. If the MIP-2 protein is not secreted, it is isolated from cell lysates. The
15 selection of the appropriate growth conditions and recovery methods are within the skill of the art.

- The recombinantly-made MIP-2 may be recovered from transformed cells in accordance with known procedures.
20 Preferably, an expression vector will be used which provides for secretion of MIP-2 from the transformed cells; thus the cells may be separated by centrifugation. MIP-2 is typically purified by general protein purification techniques, including, but not limited to,
25 size exclusion, ion-exchange chromatography, HPLC, and the like.

- Once a coding sequence for MIP-2 has been prepared or isolated, it can be cloned into any suitable vector and
10 thereby maintained in a composition of cells which is substantially free of cells that do not contain a MIP-2 coding sequence (e.g., free of other library clones). Numerous cloning vectors are known to those of skill in the art. Examples of recombinant DNA vectors for cloning
35 and host cells which they can transform include the various bacteriophage lambda vectors (E. coli), pBR322 (E. coli), pACYC177 (E. coli), pKT230 (gram-negative bacteria), pGV1106 (gram-negative bacteria), pLAFR1

(gram-negative bacteria), pME290 (non-E. coli gram-negative bacteria), pHV14 (E. coli and Bacillus subtilis), pBD9 (Bacillus), pIJ61 (Streptomyces), pUC6 (Streptomyces), actinophage, ϕ C31 (Streptomyces), YIp5
5 (Saccharomyces), YCp19 (Saccharomyces), YEp24 (Saccharomyces), pC1/1 (Saccharomyces), XRp17 (Saccharomyces), and bovine papilloma virus (mammalian cells). See generally, DNA Cloning: Vols. I & II, supra; T. Maniatis et al., supra; B. Perbal, supra;
10 Botstein et al. (1979) GENE 8: 17-24; Brake et al. (1984) PROC. NATL. ACAD. SCI. USA 81: 4642-4646; Stnichcomb et al. (1982) J. MOL. BIOL. 158: 157.

Alternatively MIP-2 may be made by conventional peptide
15 synthesis, for instance, by using the principles of the Merrifield synthesis and using commercial automatic apparatus designed to employ the methods of the Merrifield synthesis. Peptides prepared using
conventional peptide synthesis may be purified using
20 conventional affinity chromatography, gel filtration and/or RP-HPLC.

It is further intended from the nucleotide sequences that MIP-2 analogs are within the scope of the present
25 invention. Analogs, such as fragments, may be produced, for example, by pepsin digestion of MIP-2. Other analogs, such as muteins, can be produced by standard site-directed mutagenesis of MIP-2 coding sequences. Analogs exhibiting "MIP-2 activity" may be identified by
30 known in vivo and/or in vitro assays.

As mentioned above, a DNA sequence encoding MIP-2 can be prepared synthetically rather than cloned. The DNA
sequence can be designed with the appropriate codons for
35 the MIP-2 amino acid sequence. In general, one will select preferred codons for the intended host if the sequence will be used for expression. The complete sequence is assembled from overlapping oligonucleotides

prepared by standard methods and assembled into a complete coding sequence. See, e.g., Edge Nature 292:756 (1981); Nambair, et al. Science 223:1299 (1984); Jay et al. J. Biol. Chem. 259:6311 (1984).

5

Synthetic DNA sequences allow convenient construction of genes which will express MIP-2 analogs or "muteins". Alternatively, DNA encoding muteins can be made by site-directed mutagenesis of native MIP-2 genes or cDNAs, and
10 muteins can be made directly using conventional polypeptide synthesis.

Site-directed mutagenesis is generally used to create analogs from a complete coding sequence. Site-directed
15 mutagenesis is conducted using a primer synthetic oligonucleotide complementary to a single stranded phage DNA to be mutagenized except for limited mismatching, representing the desired mutation. Briefly, the synthetic oligonucleotide is used as a primer to direct
20 synthesis of a strand complementary to the phage, and the resulting double-stranded DNA is transformed into a phage-supporting host bacterium. Cultures of the transformed bacteria are plated in top agar, permitting plaque formation from single cells which harbor the
25 phage.

Theoretically, 50% of the new plaques will contain the phage having, as a single strand, the mutated form; 50% will have the original sequence. The resulting plaques
30 are hybridized with kinased synthetic primer at a temperature which permits hybridization of an exact match, but at which the mismatches with the original strand are sufficient to prevent hybridization. Plaques which hybridize with the probe are then picked, cultured,
35 and the DNA recovered.

A general method for site-specific incorporation of unnatural amino acids into proteins is described in

Christopher J. Noren, Spencer J. Anthony-Cahill, Michael C. Griffith, Peter G. Schultz, SCIENCE 244: 182-188 (April 1989). This method may be used to create analogs with unnatural amino acids.

5

The inflammatory cytokine in accordance with the present invention was isolated and analyzed in mice as set forth in Example 1. Human inflammatory cytokine (MIP-2) is presumably similar to mouse MIP-2, since the mouse MIP-2
10 has an effect upon human neutrophils. As disclosed herein, this activity of the inflammatory cytokine may be harnessed by administering the inflammatory cytokine to the situs of tissue infection to promote the delivery of neutrophils to that location.

15

As discussed earlier, the inflammatory cytokine or its binding partner(s) or other ligands or agents exhibiting either mimicry or antagonism to the cytokine or control over its production, may be prepared in pharmaceutical
20 compositions, with a suitable carrier and at a strength effective for administration by various means to a patient having a tissue infection or other pathological derangement, for the treatment thereof. A variety of administrative techniques may be utilized, among them
25 topical applications as in ointments or on surgical and other topical appliances such as, surgical sponges, bandages, gauze pads, and the like. Also, such compositions may be administered by parenteral techniques such as subcutaneous, intravenous and intraperitoneal
30 injections, including delivery in an irrigation fluid used to wash body wound areas, catheterizations and the like. Average quantities of the inflammatory cytokine may vary and in particular should be based upon the recommendations and prescription of a qualified physician
35 or veterinarian.

Also, antibodies including both polyclonal and monoclonal antibodies, and drugs that modulate the production or

activity of the inflammatory cytokine may possess certain therapeutic applications and may thus be utilized for the purpose of treating the effects of post infection attributable the action of the inflammatory cytokine, such as inflammation and fever. In particular, the inflammatory cytokine may be used to produce both polyclonal and monoclonal antibodies to itself in a variety of cellular media, by known techniques such as the hybridoma technique utilizing, for example, fused mouse spleen lymphocytes and myeloma cells.

The general methodology for making monoclonal antibodies by hybridomas is well known. Immortal, antibody-producing cell lines can also be created by techniques other than fusion, such as direct transformation of B lymphocytes with oncogenic DNA, or transfection with Epstein-Barr virus. See, e.g., M. Schreier et al., "Hybridoma Techniques" (1980); Hammerling et al., "Monoclonal Antibodies And T-cell Hybridomas" (1981); Kennett et al., "Monoclonal Antibodies" (1980); see also U.S. Patent Nos. 4,341,761; 4,399,121; 4,427,783; 4,444,887; 4,451,570; 4,466,917; 4,472,500; 4,491,632; 4,493,890.

Panels of monoclonal antibodies produced against MIP-2 peptides can be screened for various properties; i.e., isotype, epitope, affinity, etc. Of particular interest are monoclonal antibodies that neutralize the activity of MIP-2. Such monoclonals can be readily identified in MIP-2 activity assays. High affinity antibodies are also useful in immunoaffinity purification of native or recombinant MIP-2.

The resulting antibodies could also be prepared in a suitable pharmaceutical composition and administered to avert or treat the undesired condition. The exact quantities, intervals of administration and administrative techniques respecting such pharmaceutical

compositions may vary in accordance with those known in the medical arts, and upon the specific instruction of a qualified physician or veterinarian.

- 5 The present invention also relates to a variety of diagnostic applications, including methods for detecting the presence of invasive stimuli by reference to their ability to elicit the activities which are affected by the present inflammatory cytokine. As mentioned earlier,
10 the inflammatory cytokine can be used to produce antibodies to itself by a variety of known techniques, and such antibodies could then be isolated and utilized as in tests for the presence of the inflammatory cytokine in suspect mammalian hosts.

15

- Antibody(ies) to the inflammatory cytokine can be produced and isolated by standard methods including the well known hybridoma techniques. For convenience, the antibody(ies) to the inflammatory cytokine will be
20 referred to herein as Ab₁ and antibody(ies) raised in another species as Ab₂.

- The presence of inflammatory cytokine activity in mammals can be ascertained by the usual immunological procedures
25 applicable to such determinations. A number of useful procedures are known. Three such procedures which are especially useful utilize either the inflammatory cytokine labeled with a detectable label, antibody Ab₁ labeled with a detectable label, or antibody Ab₂ labeled
30 with a detectable label. The procedures may be summarized by the following equations wherein the asterisk indicates that the particle is labeled, and "Cyt" stands for the inflammatory cytokine:

- A. $\text{Cyt}^* + \text{Ab}_1 = \text{Cyt}^*\text{Ab}_1$
35 B. $\text{Cyt} + \text{Ab}^* = \text{CytAb}_1^*$
C. $\text{Cyt} + \text{Ab}_1 + \text{Ab}_2^* = \text{CytAb}_1\text{Ab}_2^*$

The procedures and their application are all familiar to those skilled in the art and accordingly may be utilized

within the scope of the present invention. The "competitive" procedure, Procedure A, is described in U.S. Patent Nos. 3,654,090 and 3,850,752. Procedure C, the "sandwich" procedure, is described in U.S. Patent
5 Nos. RE 31,006 and 4,016,043. Still other procedures are known such as the "double antibody", or "DASP" procedure.

In each instance, the inflammatory cytokine forms complexes with one or more antibody(ies) or binding
10 partners and one member of the complex is labeled with a detectable label. The fact that a complex has formed and, if desired, the amount thereof, can be determined by known methods applicable to the detection of labels.

15 It will be seen from the above, that a characteristic property of Ab_2 is that it will react with Ab_1 . This is because Ab_1 raised in one mammalian species has been used in another species as an antigen to raise the antibody Ab_2 . For example, Ab_2 may be raised in goats using rabbit
20 antibodies as antigens. Ab_2 therefore would be anti-rabbit antibody raised in goats. For purposes of this description and claims, Ab_1 will be referred to as a primary or anti-inflammatory cytokine antibody, and Ab_2 will be referred to as a secondary or anti- Ab_1 antibody.

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The labels most commonly employed for these studies are radioactive elements, enzymes, chemicals which fluoresce when exposed to ultraviolet light, and others.

30 A number of fluorescent materials are known and can be utilized as labels. These include, for example, fluorescein, rhodamine and auramine. A particular detecting material is anti-rabbit antibody prepared in goats and conjugated with fluorescein through an
35 isothiocyanate.

The inflammatory cytokine or its binding partner(s) can also be labeled with a radioactive element or with an

enzyme. The radioactive label can be detected by any of the currently available counting procedures. The preferred isotope may be selected from ^{14}C , ^{131}I , ^3H , ^{125}I and ^{35}S .

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Enzyme labels are likewise useful, and can be detected by any of the presently utilized colorimetric, spectrophotometric, fluorospectrophotometric or gasometric techniques. The enzyme is conjugated to the selected particle by reaction with bridging molecules such as carbodiimides, diisocyanates, glutaraldehyde and the like. Many enzymes which can be used in these procedures are known and can be utilized. The preferred are peroxidase, β -glucuronidase, β -D-glucosidase, β -D-galactosidase, urease, glucose oxidase plus peroxidase and alkaline phosphatase. U.S. Patent Nos. 3,654,090; 3,850,752; and 4,016,043 are referred to by way of example for their disclosure of alternate labeling material and methods.

20

A particular assay system developed and utilized in accordance with the present invention, is known as a receptor assay. In a receptor assay, the material to be assayed is appropriately labeled and then certain cellular test colonies are inoculated with a quantity of both the labeled and unlabeled material after which binding studies are conducted to determine the extent to which the labeled material binds to the cell receptors. In this way, differences in affinity between materials can be ascertained.

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Accordingly, a purified quantity of the inflammatory cytokine may be radiolabeled, after which binding studies would be carried out using for example, recently differentiated neutrophils. Solutions would then be prepared that contain various quantities of labeled and unlabeled inflammatory cytokine and cell samples would then be inoculated and thereafter incubated. The

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resulting cell monolayers are then washed, solubilized and then counted in a gamma counter for a length of time sufficient to yield a standard error of <5%. This data are then subjected to Scatchard analysis after which
5 observations and conclusions regarding material activity can be drawn. While the foregoing is exemplary, it illustrates the manner in which a receptor assay may be performed and utilized, in the instance where the cellular binding ability of the assayed material may
10 serve as a distinguishing characteristic.

In a further embodiment of this invention, commercial test kits suitable for use by a medical specialist may be prepared to determine the presence or absence of
15 inflammatory cytokine in a suspected mammalian host. In accordance with the testing techniques discussed above, one class of such kits will contain at least the labeled inflammatory cytokine or its binding partner, for instance an antibody specific thereto, and directions, of
20 course, depending upon the method selected, e.g., "competitive", "sandwich", "DASP" and the like. The kits may also contain peripheral reagents such as buffers, stabilizers, etc.

25 Accordingly, a test kit may be prepared for the demonstration of the reaction of a mammalian host to invasive stimuli, comprising:

(a) a predetermined amount of at least one labeled immunochemically reactive component obtained by the
30 direct or indirect attachment of the present inflammatory cytokine or a specific binding partner thereto, to a detectable label;

(b) other reagents; and

(c) directions for use of said kit.

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More specifically, the diagnostic test kit may comprise:

(a) a known amount of the inflammatory cytokine as described above (or a binding partner) generally bound to

a solid phase to form an immunosorbent, or in the alternative, bound to a suitable tag, or plural such end products, etc. (or their binding partners) one of each;

- (b) if necessary, other reagents; and
- 5 (c) directions for use of said test kit.

In a further variation, the test kit may be prepared and used for the purposes stated above, which operates according to a predetermined protocol (e.g.

- 10 "competitive", "sandwich", "double antibody", etc.), and comprises:

- (a) a labeled component which has been obtained by coupling the inflammatory cytokine to a detectable label;

- (b) one or more additional immunochemical reagents
- 15 of which at least one reagent is a ligand or an immobilized ligand, which ligand is selected from the group consisting of:

- (i) a ligand capable of binding with the labeled component (a);

- 20 (ii) a ligand capable of binding with a binding partner of the labeled component (a);

- (iii) a ligand capable of binding with at least one of the component(s) to be determined; and

- (iv) a ligand capable of binding with at least
- 25 one of the binding partners of at least one of the component(s) to be determined; and

- (c) directions for the performance of a protocol for the detection and/or determination of one or more components of an immunochemical reaction between the
- 30 inflammatory cytokine and a specific binding partner thereto.

In accordance with the above, an assay system for screening potential drugs effective to modulate the

- 35 synthesis, release, or activity of the inflammatory cytokine may be prepared. In a first procedure, the test drug could be administered to a stimulated macrophage sample to determine its effect upon the production of the

inflammatory cytokine. In an alternate procedure, the inflammatory cytokine may be introduced into a cellular test system such as neutrophils, and the prospective drug may also be introduced into the resulting cell culture, and the culture thereafter examined to observe any changes in the activity of the inflammatory cytokine, due either to the addition of the prospective drug alone, or due to the effect of added quantities of the known inflammatory cytokine.

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The following examples set forth the details of the isolation and identification of the present inflammatory cytokine, the observations noted as to its activity, defining both the distinctions and similarities in activity between the present inflammatory cytokine and those factors identified earlier both by applicants and by others in the field, and the cloning, sequencing and expression of the cytokine MIP-2. Naturally, the specific materials and techniques set forth hereinafter are exemplary only and may vary, so that the following is presented as illustrative but not restrictive of the present invention.

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EXAMPLE 1

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The following experiments were conducted to identify and characterize the inflammatory cytokine of the present invention. Initially, the mediator substance was cultured, the inflammatory cytokine was isolated and its structure then partially determined, after which a battery of tests were conducted in an effort to elucidate its activities, and where possible, to establish or refute identity with other known macrophage-derived factors.

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MATERIALS AND METHODS

Materials - Supernatants from COS cells transfected with plasmid containing the hamster or human gro gene or control plasmid alone were provided by A. Anisowicz and R. Sager. Partially purified human NAP-1 protein was a gift from J. Van Damme and purified human NAP-1 protein was given by T. Yoshimura and E. Leonard. All other reagents were obtained from Sigma (St. Louis, MO).

10

Animals - C3H/HeN mice were obtained from Charles River (Kingston, NY). Mice of the endotoxin-resistant C3H/HeJ strain were obtained from Jackson Laboratories (Bar Harbor, ME).

15

Cell Culture - The mouse macrophage cell line RAW 264.7 and the cachectin/TNF-sensitive cell line L929 were obtained from American Type Culture Collection (Rockville, MD) and maintained in RPMI 1640 and Dulbecco's modified MEM ((DMEM) GIBCO, Grand Island, NY), respectively. Both media were supplemented with 20mM Hepes and 10% fetal bovine serum (Hyclone, Logan, UT). For the production of stimulated RAW 264.7 supernatants, cells were grown in 150 mm tissue culture dishes (Falcon) in RPMI plus 10% fetal bovine serum until they reached confluency. The cells were washed five times in Hanks' balanced salt solution and the medium was replaced with serum-free RPMI supplemented with 1 µg/ml of lipopolysaccharide (LPS W, E. coli 0127:B8, Difco, Detroit, MI). The cells were incubated at 37°C for 16-18 hours and the supernatants filtered through 0.22 µm filters.

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Purification of MIP-2 - MIP-2 was purified using methodology previously described for MIP-1 (S.D. Wolpe, G. Davatelis, B. Sherry, B. Beutler, D.G. Hesse, H.T. Nguyen, L.L. Moldawer, C.F. Nathan, S.F. Lowry, & A. Cerami (1988), J. EXP. MED., 167:570-581). The degree of

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purification was followed by sodium dodecyl sulfate (NaDodSO₄-PAGE) with silver staining. In brief, two liters of conditioned supernatant from endotoxin-stimulated RAW 264.7 cells were concentrated and diafiltrated against 20 mM Tris-HCl buffer, pH 8.0, and applied to a Mono Q 10/10 (anion exchange) column (Pharmacia LKB Biotechnology, Rahway, NJ). Greater than 90% of the MIP-2 was observed not to bind to the column and was recovered in the effluent.

10

Peak MIP-2 containing fractions were applied to a heparin-conjugated Sepharose (Pharmacia LKB) column equilibrated with 20 mM Tris-HCl buffer, pH 8.0, and eluted with a 0-2 M NaCl linear gradient in the same buffer. MIP-2 eluted at approximately 0.75 M NaCl. Peak fractions were concentrated in a Centricon ultrafiltration device with a 3,000 dalton molecular weight cutoff (Amicon Corp., Danvers, MA) and applied to a Superose 12 (gel filtration [Pharmacia LKB]) column equilibrated with 100 mM ammonium acetate. From two liters of RAW 264.7 conditioned medium (which equalled approximately 100 mg total protein), a quantity of 0.5 mg of MIP-2 was generally isolated as assessed by Bradford protein assay (Biorad, Rockville Center, NY) using bovine gamma globulin as standard. By comparison, approximately 2 mg of MIP-1 and 1 mg of cachectin/TNF could be purified from a like batch of conditioned medium.

Immunoblot Analysis - Antisera to MIP-2 were produced in rabbits injected once subcutaneously with 10 µg of purified protein emulsified in complete Freund's adjuvant, and once one month later with 10 µg of purified protein in incomplete Freund's adjuvant. Antisera were collected one week after the second immunization.

Approximately 50 ng of pure MIP-2 or NAP-1 protein, or roughly equivalent amounts of human or hamster gamma protein from the serum-free supernatants of COS cells transfected with the appropriate vector, were subjected

to NaDodSO₄-PAGE in 10-18% linear gradient gels and transferred to nitrocellulose using a transblot apparatus (Biorad). Blots were blocked in 5% dry milk (Alba) for 1-2 hrs. and incubated in antiserum diluted 1:100 for 1 hr. at room temperature. The blots were washed three times in phosphate-buffered saline containing 0.05% Tween 20 and 0.05% thimerosal and bound antibody was detected with an alkaline phosphatase-conjugated second antibody (Promega Biotec, Madison, WI).

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PMN Chemotaxis and Activation - The assay for chemotaxis was conducted as previously described (S.D. Wolpe, G. Davatelis, B. Sherry, B. Beutler, D.G. Hesse, H.T. Nguyen, L.L. Moldawer, C.F. Nathan, S.F. Lowry, & A. Cerami (1988), J. EXP. MED., 167:570-581). In brief, chemotaxis was assayed by placing 25 μ l of chemoattractant (fMet-Leu-Phe [10^{-8} M], MIP-2 or buffer], Gey's balanced salt solution, pH 7.4 and 2% BSA)) in the bottom wells, and the top wells were filled with 45 μ l of buffer containing 1.1×10^6 PMN's (isolated by Ficoll-Hypaque density gradient centrifugation and dextran sedimentation). The two wells were separated by a cellulose nitrate membrane with a 3 μ M pore size (SM 11302; Sartorius Balances, Westbury, NY). Chambers were incubated at 37°C in a humidified 5% carbon dioxide, 95% room air chamber for 45 minutes. Membranes were removed and stained and the number of PMN's migrating into the membrane was counted every 10 μ M up to 130 μ M using an automated Optomax Imaging System (Optomax, Inc., Hollis, NH). Random migration was also determined under conditions where the gradient of chemotactic agent was abolished by including equal concentrations in the upper and lower chambers.

35 The ability of MIP-2 to elicit the release of H₂O₂ from adherent PMN's was assayed as previously described (S.D. Wolpe, G. Davatelis, B. Sherry, B. Beutler, D.G. Hesse,

H.T. Nguyen, L.L. Moldawer, C.F. Nathan, S.F. Lowry, & A. Cerami (1988), J. EXP. MED., 167:570-581).

RESULTS

- 5
- Purification of MIP-2 - As judged from silver-stained NaDodSO₄-PAGE gels, more than 90% of MIP-2 remained in the effluent of the Mono Q column (FIGURE 1). This one-step purification step was sufficient to remove contaminating
- 10 MIP-1 and cachectin/TNF. As previously shown (Wolpe, et al., supra), these two proteins bind to the Mono Q column under these loading conditions and elute at approximately 0.37 M NaCl. Two successive steps of heparin-affinity chromatography and gel filtration were sufficient to
- 15 purify MIP-2 protein to homogeneity (FIGURE 1). MIP-2 eluted from heparin-Sepharose column at approximately 0.75 M NaCl and migrated with an apparent molecular weight of 10,000 daltons on gel filtration.
- 20 Analysis of partial NH₂-terminal amino acid sequence data of purified MIP-2 (FIGURE 2) revealed a unique sequence. Comparison with other sequences present in the Dayhoff bank using the d-FAST-P program (D.J. Lipman and W.R. Pearson (1985), SCIENCE, 227:1435-1441) revealed
- 25 similarity to a family of proteins with sequence relatedness to platelet factor 4. FIGURE 2 depicts the partial NH₂-terminal amino acid sequences of MIP-2 and various members of this family aligned by a conserved cysteine residue. FIGURE 3 depicts a comparison of the
- 30 percent sequence identity over the region corresponding to the partial amino acid sequence obtained for MIP-2. The closest relationship observed to MIP-2 was with the predicted amino acid sequence for the gro gene product. The MIP-2 sequence is 62.5% identical with human gro and
- 35 68.7% identical with hamster gro. This relationship increases to 88% in both cases when amino acid changes which could result from a single base change are taken into consideration.

The similarity in amino acid sequence between MIP-2 and gro suggested that MIP-2 could be the murine equivalent of gro. The predicted murine KC gene product ("KC"),
5 however, showed a closer relationship (65.6% identity to human gro and 81.2% identity to hamster gro for KC versus 62.5% and 68.7% respectively for MIP-2) when compared over the same region as the partial sequence for MIP-2. Similar results were obtained when the comparisons were
10 conducted over the entire sequence, KC was 68% identical to human gro and 85% to hamster gro. Human and hamster gro were 68% identical when compared to each other over their entire sequence.

15 Immunoblot Analysis - In order to further characterize the relationship between MIP-2 and the other members of the platelet factor 4 family, a rabbit polyclonal antiserum was raised against MIP-2. The antiserum reacted monospecifically against serum-free supernatants
20 from endotoxin-stimulated RAW 264.7 cells or thioglycollate-elicited mouse macrophages but did not recognize any proteins in supernatants from unstimulated cells. An example of such a blot with antibody against MIP-2 is shown in parts a and b of FIGURE 4. Preimmune
25 serum also showed no reactivity. In particular, antiserum to MIP-2 did not cross-react with MIP-1 or cachectin/TNF (see, for example, lane 2 of FIGURE 4). Rabbit anti-MIP-2 cross-reacted weakly with human and hamster gro but did not cross-react with purified human
30 NAP-1 protein (FIGURE 4). Similarly, no cross-reaction was seen with partially purified human NAP-1 from another laboratory (supplied by J. Van Damme). In addition, the human myelomonocytic cell line HL60 secreted a
35 cross-reacting protein after stimulation with 10^{-7} M phorbol myristic acid, further suggesting that the lack of reactivity of anti-MIP-2 antibody with the human NAP-1 protein is due to lack of immunological relatedness rather than to species specificity. The nature of the

cross-reacting material from HL60 cells is under investigation.

PMN Chemotaxis and Activation - Because other members of the PF4 family have been shown to be chemotactic for and to activate PMN's, the effect of MIP-2 on these cells was studied. MIP-2 was significantly chemotactic for human PMN's at 10 ng/ml and was more chemotactic for PMN's than fMet-Leu-Phe at concentrations greater than 100 ng/ml (FIGURE 5). When equal concentrations of MIP-2 were added to both sides of the membrane, no increase in migration was observed. Thus, the activity of MIP-2 at the concentrations tested appears to be due to stimulation of directed migration of the cells rather than enhancement of random migration.

PMN's did not undergo an oxidation burst (as measured by production of hydrogen peroxide) when treated with concentrations of MIP-2 ranging from 10 ng to 1 µg per ml.

In addition to these in vitro assays, MIP-2 was tested in vivo by injection of 100 ng into the footpads of endotoxin-resistant C3H/HeJ mice. This injection induced a leukocyte infiltrate similar in magnitude to that previously shown for MIP-1.

DISCUSSION

MIP-2 has a molecular mass of approximately 6,000 daltons on NaDodSO₄-PAGE and fractionates from a gel filtration column with an apparent molecular mass of approximately 10,000 daltons. In contrast to MIP-1 or cachectin/TNF, MIP-2 is cationic and does not bind to an anion exchange column equilibrated at pH 8.0. This property made separation of these activities and subsequent purification of MIP-2 relatively straightforward. After removal of the majority of contaminating proteins by

anion exchange, MIP-2 was purified to homogeneity by sequential heparin affinity chromatography eluting at approximately 0.75M NaCl and gel filtration.

- 5 MIP-2 is an extremely active chemotactic agent but induces little or no chemokinetic activity at the doses tested. At 10 ng/ml (1.7×10^{-9} M), MIP-2 is significantly chemotactic for human PMN's and at concentrations greater than 100 ng/ml (1.7×10^{-8} M) MIP-2
10 exhibits a higher leukotactic index than fMet-Leu-Phe at the latter's optimum concentration of 10^{-8} M. Studies indicate that MIP-2 can also induce degranulation of PMN's with release of lysozyme but not β -glucuronidase. Murine MIP-2 did not, however, induce the respiratory
15 burst in human PMN's. It is not yet clear whether this is due to species specificity or is an inherent property of the molecule.

- The above effects on PMN's are similar to observations
20 made with a protein isolated from human mononuclear cells by a number of investigators and variously referred to as "310C", "MDNCF", "MONAP", "NAF" or "GCP" [Schmid, J. & Weissmann, C. (1987) J. IMMUN. 139:250-256; Yoshimura, T., Matsushima, K., Oppenheim, J.J. & Leonard, E.J.
25 (1987) J. IMMUN. 139:788-793; Yoshimura, T., Matsushima, K., Tanaka, S., Robinson, E.A., Appella, E., Oppenheim, J.J. and Leonard, E.J. 1987. PROC. NATL. ACAD. SCI. USA 84:923-9237; Schroder, J.M., Mrowietz, U., Morita, E. & Christophers, E. (1987) J. IMMUN. 139:3474-3483; Walz, A., Peveri, P., Aschauer, H. & Baggiolini, M. (1987)
30 BIOCH. BIOPHYS. RES. COMM. 149:755-761; Peveri, P., Walz, A., Dewald, B. and Baggiolini, M. (1988) J. Exp. Med. 167:1547-1559; Van Damme, J., Beeumen, J.V., Opdenakker, G. and Billiau, A. (1988) J. EXP. MED. 167:1364-1376.]
35 This protein is now known as "neutrophil activating protein-1" (NAP-1). Because of the striking similarity in properties of MIP-2 and NAP-1, the possibility was considered that MIP-2 might be the murine equivalent of

NAP-1. This relationship appears not to be the case based on both sequence and immunological analyses. Comparison of the N-terminal sequence of MIP-2 with the PF-4 family using the FASTP program shows a 47% identity with NAP-1 but a 63% and 69% identity with human and hamster gro, respectively. This relationship agrees well with the immunoblotting results which demonstrated cross-reactivity with hamster and human gro but not with NAP-1 from two different laboratories.

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It also appears unlikely that MIP-2 is the murine equivalent of gro because the predicted murine KC gene product shows an even higher sequence identity to gro, especially in the case of hamster gro. Applicants therefore conclude that MIP-2 is a novel gene product closely related to, but separate from, gro or KC.

It is of interest that the gro and KC genes were originally found in studies on the control of cell growth. The gro gene was isolated by differential hybridization of DNA from transformed cells [Anisowicz, A., Bardwell, L. and Sager, R. (1987) PROC. NATL. ACAD. SCI. USA 84:P7188-7192]; the KC gene was isolated by differential hybridization of DNA from cells treated with platelet-derived growth factor [Cochran, B.H., Reffel, A.C. and Stiles, C.D. (1983) CELL 33:939-947]. Transfection of cells with the gro gene does not lead to transformation, however [Anisowicz, A., Bardwell, L. and Sager, R. (1987) PROC. NATL. ACAD. SCI. USA 84:P7188-7192]. Similarly, treatment of density-arrested 3T3 fibroblasts with MIP-2 or MIP-2 plus limiting amounts of serum or plasma does not increase uptake of ³H thymidine.

35

EXAMPLE 2

The following sets forth the cloning and expression of MIP-2. The cloning of the cDNA for murine MIP-2 was as

follows. A degenerate oligonucleotide probe pool corresponding to amino acids 9-14 of a partial NH₂-terminal sequence of MIP-2 was synthesized. This portion of the partial sequence was chosen because of its lower
5 codon degeneracy when compared with the remainder of the sequence. The resulting probe was a 128 fold degenerate pool of oligomers 17 nucleotides in length.

A cDNA library was constructed from Poly(A)⁺ RNA isolated
10 from E. coli lipopolysaccharide-stimulated RAW 264.7 cells as taught in Davatelis et al., J. EXP. MED. 167: 1939-1941 (1988) and Sherry et al. J. EXP. MED. 168: 2251-2259 (1988). Duplicate nitrocellulose filter lifts of the plated library (5x10⁵ plaques) were hybridized at
15 42°C in 5xSSC, 1x Denhardt's, 20mm sodium phosphate buffer, pH6.5, 50% formamide, 10% dextran sulfate, 0.1% SDS, 0.1 mg/ml sonicated salmon sperm DNA and 5x10⁴ cpm per ml per degeneracy of ³²P-ATP 5' end-labelled synthetic oligonucleotide probe pool. Following hybridization the
20 filters were washed employing the TMAC washing procedure described by Wood et al. PROC. NATL. ACAD. SCI. USA 82: 1585 (1985). Plaques that were positive on duplicate filters were subjected to a second round of low density plating and screening. Four independent positive phage
25 clones were isolated from which DNA was prepared for further analysis. cDNA inserts were excised by digestion with EcoRI and subcloned into M13 phage vector. DNA sequencing was performed by the dideoxy chain termination method of Sanger et al. PROC. NATL. ACAD. SCI. USA 74:
30 5463 (1977). The nucleotide sequence of one of the inserts was determined and found to encode a secreted protein that includes the amino acid sequence determined from amino terminal sequencing of purified native MIP-2. The sequence of the cDNA clone and the predicted protein
35 sequence are shown in FIGURE 7.

Construction of Expression Plasmid pYMIP400

This plasmid encodes an α -factor leader linked to the mature coding sequence of MIP-2. The MIP-2 mature coding sequence was derived from the MIP-2 cDNA determined
 5 above. The GAPDH promoter sequence, the α -factor leader sequence and the α -factor transcription terminator were derived from plasmid pGAI1, the construction of which is described in European Publication No. 324,274, published
 10 19 July 1989, the disclosure of which is incorporated herein by reference.

A BglIII site was introduced by in vitro mutagenesis into the nucleotide sequence encoding the carboxyl terminus of MIP-2 in order to facilitate cloning into the expression
 15 vector. The mutagenic primer was:

**

5' - CAAAAGATCTTGAACAAAG - 3'

(*denotes base changes from original cDNA sequence)

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Following verification of the altered cDNA sequence, phage RF was prepared and digested with BalI and BglIII. A 1966 bp fragment encoding most of the mature MIP-2 (lacking the sequence encoding 2 N-terminal and 9 C-terminal amino acids) was isolated. Plasmid pGAI1
 25 described in European Publication No. 324,274, published 19 July 1989, was digested with KpnI and ligated to the following adaptor which encodes the 3 alpha factor leader carboxyl terminal amino acids, the LysArg processing site
 30 and the first 3 amino acids of mature MIP-2.

KpnI - BalI adaptor

5'	CCTTGGATAAAAGAGCTGTTGTGG	3'
3'	CATGGGAACCTATTTTCTCGACAACACC	5'

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Following digestion with SalI, the following BglIII - SalI adaptor was added which encodes for the 8 carboxyl

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terminal amino acids of MIP-2 as well as translational stop codons.

BglII - SalI adaptor

5' GATCTTGAACAAAGGCAAGGCTAACTGATAGCGTCG 5'
3' AACTTGTTCGGTTCGATTGACTATCGCAGCAGCT 3'

The modified vector is gel purified and ligated to the 1966 bp BalI-BglII fragment described above, after which screening to isolate plasmid pMIP400 is conducted. The plasmid is then isolated, and its nucleotide sequence across the adaptors is verified, after which the BamHI expression cassette from this plasmid is isolated and cloned into the BamHI site of pAB24 to give the expression plasmid pYMIP400.

Expression of MIP-2

S. cerevisiae strain MB2-1 (leu2-3, leu2-112, his3-11, his3-15, ura3⁺, pep4⁺, CAN^r, cir^o) is transformed with plasmid pYMIP400 by standard procedures and transformants selected for ura prototrophy. Expression is analyzed by inoculation of single colonies of individual transformants into leucine selective medium, and growing for -48 hr. Cultures are then centrifuged, cells resuspended in medium lacking uracil and diluted 20 fold into ura selective medium. Cultures are grown for approximately 72 hr, then harvested and cell-free supernatants prepared. Conditioned medium is analyzed for the presence of MIP-2 by SDS-PAGE followed by coomassie staining and immunoblotting.

This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present disclosure is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended Claims, and

all changes which come within the meaning and range of
equivalency are intended to be embraced therein.

WHAT IS CLAIMED IS:

1 1. An inflammatory cytokine comprising a protein in
2 purified form capable of binding to heparin, inducing
3 localized inflammation characterized by polymorphonuclear
4 cell infiltration when administered subcutaneously and
5 having potent in vitro chemotactic activity while
6 inducing little or no in vitro chemokinesis in
7 polymorphonuclear cells, while lacking the ability to
8 suppress the activity of the anabolic enzyme lipoprotein
9 lipase, cause the cytotoxicity of cathectin/TNF-sensitive
10 cells, stimulate the blastogenesis of endotoxin-resistant
11 C3H/HeJ thymocytes, or induce the production of
12 cachectin/TNF by primary thioglycollate-elicited mouse
13 macrophage cells.

1 2. The inflammatory cytokine of Claim 1 wherein said
2 cytokine is cationic under physiological conditions and
3 binds to heparin at high salt concentrations.

1 3. The inflammatory cytokine of Claim 1 wherein said
2 cytokine is incapable of inducing fever in rabbits or
3 inducing superoxide formation or respiratory burst in
4 human neutrophils in vitro.

1 4. The inflammatory cytokine of Claim 1 wherein said
2 cytokine is derivable from animal macrophage cells that
3 may have been incubated with a stimulator material such
4 as might accompany an invasive stimulus.

1 5. The inflammatory cytokine of Claim 1 comprising an
2 amino acid sequence substantially homologous to the 74
3 amino acid sequence set forth in Figure 7.

1 6. The inflammatory cytokine of either of Claims 1 or 5
2 labeled with a detectable label.

- 1 7. The inflammatory cytokine of Claim 6 wherein the
2 label is selected from enzymes, chemicals which fluoresce
3 and radioactive elements.
- 1 8. A composition comprising mature macrophage
2 inflammatory protein 2 (mMIP-2) substantially free of
3 other polypeptides.
- 1 9. A polypeptide comprising an amino acid sequence
2 substantially homologous to the 74 amino acid sequence of
3 mMIP-2 set forth in Figure 7.
- 1 10. A DNA molecule comprising a replicon and a
2 heterologous coding sequence which encodes mMIP-2.
- 1 11. A DNA molecule comprising a coding sequence for
2 mMIP-2 under the control of transcriptional and
3 translational control sequences which are capable of
4 effecting the expression of said coding sequence in a
5 host cell, wherein at least one of said transcriptional
6 and translational control sequences is heterologous to
7 said coding sequence.
- 1 12. The DNA molecule of Claim 10 wherein said coding
2 sequence is uninterrupted by introns.
- 1 13. A composition of cells transformed by the DNA
2 molecule of Claim 10 substantially free of cells that are
3 not transformed by said DNA molecule.
- 1 14. The cells of Claim 13 which are prokaryotic cells.
- 1 15. The cells of Claim 13 which are mammalian cells.
- 1 16. The cells of Claim 13 which are yeast cells.
- 1 17. A method for producing mMIP-2 which comprises
2 culturing the composition of cells transformed by a DNA

3 molecule according to Claim 11 under conditions whereby
4 said mMIP-2 is expressed, and recovering the expressed
5 mMIP-2.

1 18. The method of Claim 17 wherein said cells are
2 prokaryotic.

1 19. The method of Claim 17 wherein said cells are
2 eukaryotic.

1 20. The method of Claim 19 wherein said cells are yeast.

1 21. A method for preparing an inflammatory cytokine
2 capable of binding to heparin, inducing localized
3 inflammation characterized by polymorphonuclear cell
4 infiltration when administered subcutaneously and having
5 potent in vitro chemotactic activity while inducing
6 little or no in vitro chemokinesis in polymorphonuclear
7 cells, while lacking the ability to suppress the activity
8 of the anabolic enzyme lipoprotein lipase, cause the
9 cytotoxicity of cachectin/TNF-sensitive cells, stimulate
10 the blastogenesis of endotoxin-resistant C3H/HeJ
11 thymocytes, or induce the production of cachectin/TNF by
12 primary thioglycollate-elicited mouse macrophage cells
13 comprising:

- 14 A. gathering a sample of cells from a mammal;
- 15 B. incubating a portion of said cells with a
16 stimulator material associated with an invasive event for
17 a mammal;
- 18 C. inducing said cells to produce said
19 inflammatory cytokine; and
- 20 D. isolating said inflammatory cytokine from a
21 supernatant harvested from the mass of said cells.

1 22. The method of Claim 21 wherein said stimulator
2 material comprises endotoxin.

1 23. An antibody to a inflammatory cytokine, the
2 inflammatory cytokine to which said antibody is raised
3 comprising a protein in purified form capable of binding
4 to heparin, inducing localized inflammation characterized
5 by polymorphonuclear cell infiltration when administered
6 subcutaneously and having potent in vitro chemotactic
7 activity while inducing little or no in vitro
8 chemokinesis in polymorphonuclear cells, while lacking
9 the ability to suppress the activity of the anabolic
10 enzyme lipoprotein lipase, cause the cytotoxicity of
11 cachectin/TNF-sensitive cells, stimulate the
12 blastogenesis of endotoxin-resistant C3H/HeJ thymocytes,
13 or induce the production of cachectin/TNF by primary
14 thicglycollate-elicited mouse macrophage cells.

1 24. The antibody of Claim 23 comprising a polyclonal
2 antibody.

1 25. The antibody of Claim 23 comprising a monoclonal
2 antibody.

1 26. An immortal cell line that produces a monoclonal
2 antibody according to Claim 25.

1 27. The antibody of Claims 23 labeled with a detectable
2 label.

1 28. The antibody of Claim 27 wherein the label is
2 selected from enzymes, chemicals which fluoresce and
3 radioactive elements.

1 29. A method for measuring the presence of an
2 inflammatory cytokine capable of binding to heparin,
3 inducing localized inflammation characterized by
4 polymorphonuclear cell infiltration when administered
5 subcutaneously and having potent in vitro chemotactic
6 activity while inducing little or no in vitro
7 chemokinesis in polymorphonuclears cells, while lacking

8 the ability to suppress the activity of the anabolic
9 enzyme lipoprotein lipase, cause the cytotoxicity of
10 cachectin/TNF-sensitive cells, stimulate the
11 blastogenesis of endotoxin-resistant C3H/HeJ thymocytes,
12 or induce the production of cachectin/TNF by primary
13 thioglycollate-elicited mouse macrophage cells, wherein
14 said inflammatory cytokine is measured by:

15 A. preparing at least one sample of said
16 inflammatory cytokine from animal cells that have been
17 exposed to a corresponding number of distinct known
18 invasive stimuli;

19 B. preparing at least one corresponding
20 antibody or binding partner directed to said inflammatory
21 cytokine samples;

22 C. placing a detectible label on a material
23 selected from the group consisting of said inflammatory
24 cytokine samples and said antibody or binding partners
25 thereto;

26 D. immobilizing a material selected from the
27 group consisting of the material from Step C that is not
28 labeled; and a biological sample from a mammal in which
29 said inflammatory cytokine is suspected, on a suitable
30 substrate;

31 E. placing the labeled material from Step C
32 in contact with said biological sample, and in contact
33 with the immobilized material;

34 F. separating the material from Step C that
35 is bound to said immobilized material from material from
36 Step C not bound to said immobilized material; and

37 G. examining said bound material for the
38 presence of said labeled material.

1 30. A method for measuring the binding sites for an
2 inflammatory cytokine capable of binding to heparin,
3 inducing localized inflammation characterized by
4 polymorphonuclear cell infiltration when administered
5 subcutaneously and having potent in vitro chemotactic
6 activity while inducing little or no in vitro

7 chemokinesis in polymorphonuclears cells, while lacking
8 the ability to suppress the activity of the anabolic
9 enzyme lipoprotein lipase, cause the cytotoxicity of
10 cachectin/TNF-sensitive cells, stimulate the
11 blastogenesis of endotoxin-resistant C3H/HeJ thymocytes,
12 or induce the production of cachectin/TNF by primary
13 thioglycollate-elicited mouse macrophage cells, wherein
14 the binding sites for said inflammatory cytokine are
15 measured by:

16 A. preparing at least one sample of said
17 inflammatory cytokine from a corresponding number of
18 distinct known invasive stimuli;

19 B. placing a detectible label on said
20 inflammatory cytokine sample;

21 C. placing the labeled inflammatory cytokine
22 sample in contact with a biological sample from a mammal
23 in which binding sites for said cytokine are suspected;
24 and

25 D. examining said biological sample in binding
26 studies for the presence of said labeled inflammatory
27 cytokine sample.

1 31. The method of Claim 29 comprising a method for
2 measuring the presence of an inflammatory cytokine
3 associated with a given invasive stimulus in mammals.

1 32. The method of Claim 31 wherein said invasive
2 stimulus is an infection.

1 33. The method of Claim 31 wherein said invasive
2 stimulus is selected from the group consisting of
3 bacterial infection, viral infection, protozoan
4 infection, tumorous mammalian cells, and toxins.

1 34. The method of Claim 29 comprising a method for
2 determining the presence of invasive or idiopathic
3 stimuli in mammals.

1 35. A method of testing the ability of a drug to
2 modulate the production and/or activity of an
3 inflammatory cytokine capable of reacting with a receptor
4 for the inflammatory cytokine on cells in the mammalian
5 body which comprises culturing a colony of test cells
6 which has said receptor in a growth medium containing the
7 inflammatory cytokine, adding the drug under test and
8 thereafter measuring the reactivity of said drug with the
9 said receptor on said colony of test cells, said
10 inflammatory cytokine comprising a protein material
11 capable of binding to heparin, inducing localized
12 inflammation characterized by polymorphonuclear cell
13 infiltration when administered subcutaneously and having
14 potent in vitro chemotactic activity while inducing
15 little or no in vitro chemokinesis in polymorphonuclear
16 cells, while lacking the ability to suppress the activity
17 of the anabolic enzyme lipoprotein lipase, cause the
18 cytotoxicity of cachectin/TNF-sensitive cells, stimulate
19 the blastogenesis of endotoxin-resistant C3H/HeJ
20 thymocytes, or induce the production of cachectin/TNF by
21 primary thioglycollate-elicited mouse macrophage cells.

1 36. An assay system for screening drugs and other agents
2 for ability to modulate production and/or activity of an
3 inflammatory cytokine comprising an observable cellular
4 test colony inoculated with an inflammatory cytokine
5 comprising a protein capable of binding to heparin,
6 inducing localized inflammation characterized by
7 polymorphonuclear cell infiltration when administered
8 subcutaneously and having potent in vitro chemotactic
9 activity while inducing little or no in vitro
10 chemokinesis in polymorphonuclear cells, while lacking
11 the ability to suppress the activity of the anabolic
12 enzyme lipoprotein lipase, cause the cytotoxicity of
13 cachectin/TNF-sensitive cells, stimulate the
14 blastogenesis of endotoxin-resistant C3H/HeJ thymocytes,
15 or induce the production of cachectin/TNF by primary
16 thioglycollate-elicited mouse macrophage cells.

- 1 37. A test kit for the demonstration of an inflammatory
2 cytokine in serum or an aqueous medium, comprising:
3 A. a predetermined amount of at least one
4 labeled immochemically reactive component obtained by the
5 direct or indirect attachment of said inflammatory
6 cytokine or a specific binding partner thereto, to a
7 detectable label, said inflammatory cytokine comprising a
8 protein capable of binding to heparin, inducing localized
9 inflammation characterized by polymorphonuclear cell
10 infiltration when administered subcutaneously and having
11 potent in vitro chemotactic activity while inducing
12 little or no in vitro chemokinesis in polymorphonuclear
13 cells, while lacking the ability to suppress the activity
14 of the anabolic enzyme lipoprotein lipase, cause the
15 cytotoxicity of cachectin/TNF-sensitive cells, stimulate
16 the blastogenesis of endotoxin-resistant C3H/HeJ
17 thymocytes, or induce the production of cachectin/TNF by
18 primary thioglycollate-elicited mouse macrophage cells;
19 B. other reagents; and
20 C. directions for use of said kit.

- 1 38. A method of treating inflammation in mammals,
2 comprising administering to a mammal an
3 inflammation-reducing amount of a material selected from
4 the group consisting of an antibody specific to an
5 inflammatory cytokine; an agent capable of inhibiting the
6 production of said inflammatory cytokine, an agent not an
7 antibody to said inflammatory cytokine capable of acting
8 as an antagonist to said inflammatory cytokine, and
9 mixtures thereof, said inflammatory cytokine comprising a
10 protein that is capable of binding to heparin, inducing
11 localized inflammation characterized by polymorphonuclear
12 cell infiltration when administered subcutaneously and
13 having potent in vitro chemotactic activity while
14 inducing little or no in vitro chemokinesis to
15 polymorphonuclear cells, while lacking the ability to
16 suppress the activity of the anabolic enzyme lipoprotein

17 lipase, cause the cytotoxicity of cachectin/TNF-
18 sensitive cells, stimulate the blastogenesis of
19 endotoxin-resistant C3H/HeJ thymocytes, or induce the
20 production of cachectin/TNF by primary
21 thioglycollate-elicited mouse macrophage cells.

1 39. A method for preventing the occurrence of
2 inflammation and/or fever in a mammal comprising,
3 administering to said mammal an amount of a material
4 selected from the group consisting of an antibody
5 specific to an inflammatory cytokine, an agent capable of
6 inhibiting the production of said inflammatory cytokine,
7 an agent not an antibody to said inflammatory cytokine
8 capable of acting as an antagonist to said inflammatory
9 cytokine, and mixtures thereof, effective to avert the
10 onset of said inflammation and/or said fever, said
11 inflammatory cytokine comprising a protein that is
12 capable of binding to heparin, inducing localized
13 inflammation characterized by polymorphonuclear cell
14 infiltration when administered subcutaneously and having
15 potent in vitro chemotactic activity while inducing
16 little or no in vitro chemokinesis in polymorphonuclear
17 cells, while lacking the ability to suppress the activity
18 of the anabolic enzyme lipoprotein lipase, cause the
19 cytotoxicity of cachectin/TNF-sensitive cells, stimulate
20 the blastogenesis of endotoxin-resistant C3H/HeJ
21 thymocytes, or induce the production of cachectin/TNF by
22 primary thioglycollate-elicited mouse macrophage cells.

1 40. A method of treating infectious and noninfectious
2 diseases in a mammal, comprising administering to said
3 mammal an disease-reducing amount of a material selected
4 from the group consisting of an inflammatory cytokine, an
5 agent capable of promoting the production and/or activity
6 of said inflammatory cytokine, an agent capable of
7 mimicking the activity of said inflammatory cytokine, and
8 mixture thereof, said inflammatory cytokine comprising a
9 protein that is capable of binding to heparin, inducing

10 localized inflammation characterized by polymorphonuclear
11 cell infiltration when administered subcutaneously and
12 having potent in vitro chemotactic activity while
13 inducing little or no in vitro chemokinesis in
14 polymorphonuclear cells, while lacking the ability to
15 suppress the activity of the anabolic enzyme lipoprotein
16 lipase, cause the cytotoxicity of cachectin/TNF-sensitive
17 cells, stimulate the blastogenesis of endotoxin-resistant
18 C3H/HeJ thymocytes, or induce the production of
19 cachectin/TNF by primary thioglycollate-elicited mouse
20 macrophage cells.

1 41. A pharmaceutical composition for the treatment of
2 inflammation and/or fever in mammals, comprising:
3 A. a therapeutically effective amount of a
4 material selected from the group consisting of an
5 antibody to an inflammatory cytokine, an agent capable of
6 inhibiting the production of said inflammatory cytokine,
7 an agent not an antibody to said inflammatory cytokine
8 capable of antagonizing the activity of said inflammatory
9 cytokine, and mixtures thereof, or a specific binding
10 partner thereto, said inflammatory cytokine comprising a
11 protein that is capable of binding to heparin, inducing
12 localized inflammation characterized by polymorphonuclear
13 cell infiltration when administered subcutaneously and
14 having potent in vitro chemotactic activity while
15 inducing little or no in vitro chemokinesis in
16 polymorphonuclear cells, while lacking the ability to
17 suppress the activity of the anabolic enzyme lipoprotein
18 lipase, cause the cytotoxicity of cachectin/TNF-sensitive
19 cells, stimulate the blastogenesis of endotoxin-resistant
20 C3H/HeJ thymocytes, or induce the production of
21 cachectin/TNF by primary thioglycollate-elicited mouse
22 macrophage cells; and

23 B. a pharmaceutically acceptable carrier.

1 42. A pharmaceutical composition for the treatment of
2 infectious and non-infectious diseases in mammals,
3 comprising:

4 A. a therapeutically effective amount of a
5 material selected from the group consisting of an
6 inflammatory cytokine, an agent capable of promoting the
7 production and/or activity of said inflammatory cytokine,
8 an agent capable of mimicking the activity of said
9 inflammatory cytokine, and mixtures thereof, said
10 inflammatory cytokine comprising a protein, in purified
11 form that is capable of binding to heparin, inducing
12 localized inflammation characterized by polymorphonuclear
13 cell infiltration when administered subcutaneously and
14 having potent in vitro chemotactic activity while
15 inducing little or no in vitro chemokinesis in
16 polymorphonuclear cells, while lacking the ability to
17 suppress the activity of the anabolic enzyme lipoprotein
18 lipase, cause the cytotoxicity of cachectin/TNF-sensitive
19 cells, stimulate the blastogenesis of endotoxin-resistant
20 C3H/HeJ thymocytes, or induce the production of
21 cachectin/TNF by primary thioglycollate-elicited mouse
22 macrophage cells, or a specific binding partner thereto;
23 and

24 B. a pharmaceutically acceptable carrier.

1 / 7

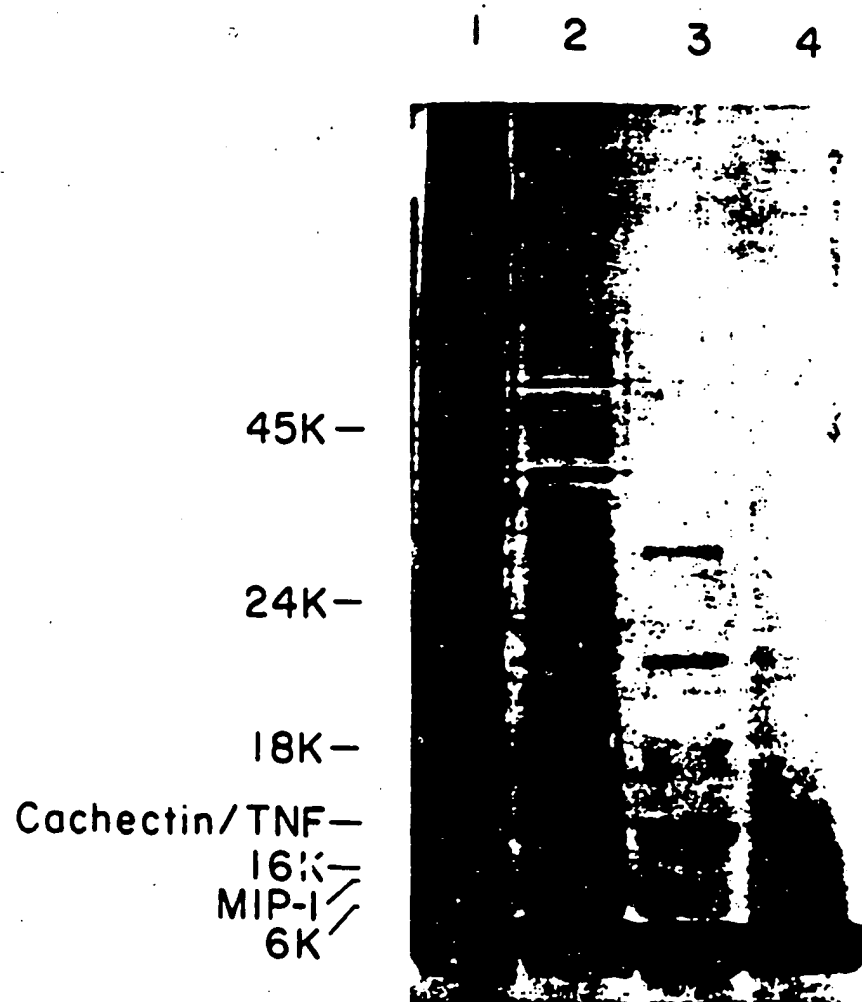


FIG. 1

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mIP-2	AVVASELRQCCLKT	LPRVDFKMTIQSLSVTPPG
hPF-4	EAEEDGDLQCLCVKT	TSQVRPRHITSLEVIKAG
bPF-4	ESSFPATFVPLPADSEGGEDELQCVCLKT	TSGINPRHISSELEVIKAG
rPF-4	VTRASPEESDGDLSQCVCKT	SSSRHILKKRITTSLEVIKAG
mBP	SSTKGQTKRMLAKGKEESLDSOLYAEELRCMCKT	TSGIMPKNIQSLEVIKAG
hNAP-1	AVLPRSAKIELRCQCKT	YSKPFHPKFIKELRVIESG
hIP10	VPLSRTVRCICIST	SNQPVMPRSLEKLEIIPAS
c9E3	ALSQGRITLVKMGNELRCQCKIST	HSKFHPKXSITQDVKLTSPG
hGro	RRAAGASVATELRQCCLQT	LQGIHPKMIQSVMVKSPG
hamGro	RLATGAPVANELRCQCLQT	MTGVHLKMIIESLKVTPPG
mKC	RLATGAPIANELRCQCLQT	HAGIHLKMIQSLSKVLPSG

FIG. 2

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	bPF-4	rPF-4	hPBP	c9E3	hNAP-1	hIP10	hGro	hamGro	mKC	mHIP-2
hPF-4	68.7	65.6	53.5	26.6	39.2	37	33.3	37	33.3	39.2
bPF-4	--	60	66.6	30	39.2	33.3	44.4	39.2	42.8	40.7
rPF-4		--	55.1	33.3	46.4	32.1	39.2	42.8	46.4	41.3
hPBP			--	53.5	57.1	32.1	60.7	55.5	62.9	53.5
c9E3				--	50	27.2	48.3	48.3	54.8	41.9
hNAP-1					--	26.6	46.6	46.6	50	46.6
hIP10						--	Ins.	Ins.	Ins.	Ins.
hGro							--	65.6	65.6	62.5
hamGro								--	81.2	68.7
mKC									--	59.3

FIG. 3

4 / 7

1 2 3 4 5 6 7 8

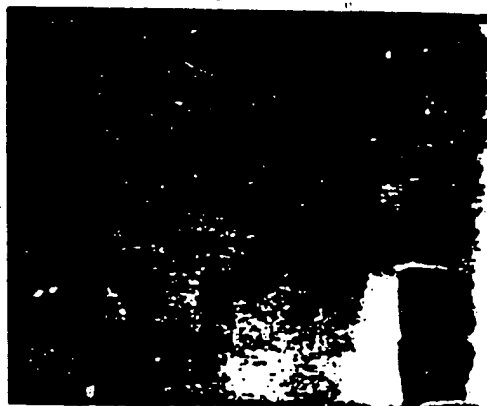


FIG.4B

1 2 3 4 5 6 7 8

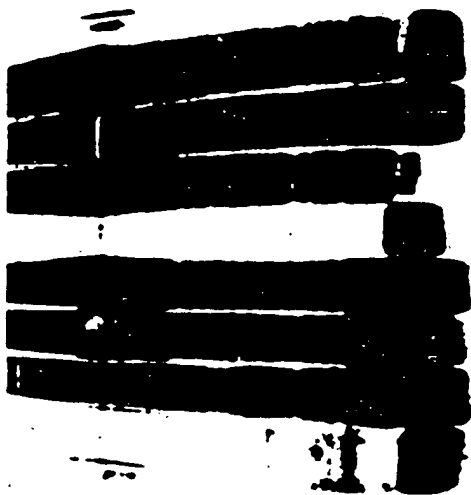


FIG.4A

45K—

24K—

18K—

Cohectin/TNF—

16K—

MIP-I—

6K—

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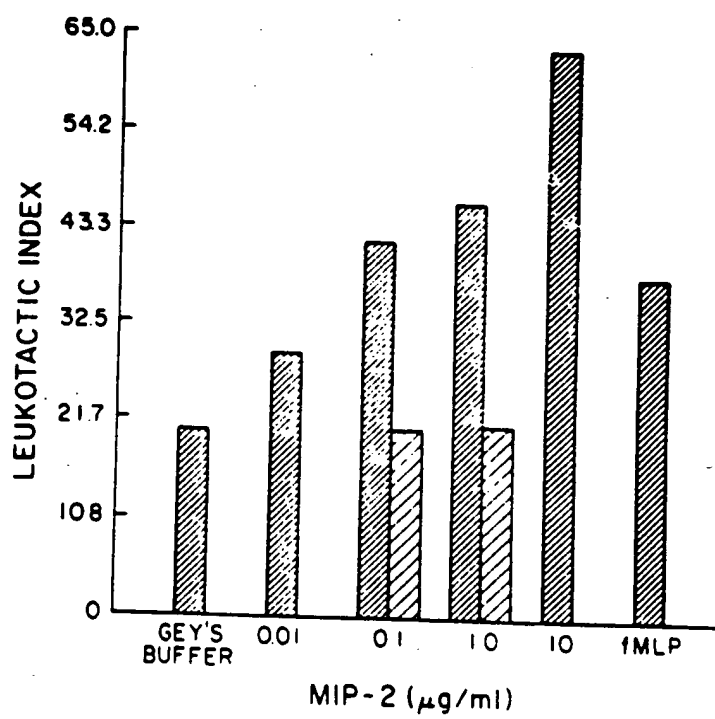


FIG. 5

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ALA VAL VAL ALA SER GLU LEU ARG CYS GLN CYS LEU LYS THR LEU PRO
ARG VAL ASP PHE LYS ASN ILE GLN SER LEU SER VAL THR PRO PRO GLY

FIG. 6

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-26
Met

-20

-10

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70

74

Ala Pro Pro Thr Cys Arg Leu Leu Ser Ala Ala Leu Val Leu Leu
GCC CCT CCC ACC TGC CGG CTC CTC AGT GCT GCA CTG GTC CTG CTG

Leu Leu Leu Ala Thr Asn His Gln Ala Thr Gly Ala Val Val Ala
CTG CTG CTG GCC ACC AAC CAC CAG GCT ACA GGG GCT GTT GTG GCC

Ser Glu Leu Arg Cys Gln Cys Leu Lys Thr Leu Pro Arg Val Asp
AGT GAA CTG CGC TGT CAA TGC CTG AAG ACC CTG CCA AGG GTT GAC

Phe Lys Asn Ile Gln Ser Leu Ser Val Thr Pro Pro Gly Pro His
TTC AAG AAC ATC CAG AGC TTG AGT GTG ACG CCC CCA GGA CCC CAC

Cys Ala Gln Thr Glu Val Ile Ala Thr Leu Lys Gly Gly Gln Lys
TGC GCC CAG ACA GAA GTC ATA GCC ACT CTC AAG GGC GGT CAA AAA

Val Cys Leu Asp Pro Glu Ala Pro Leu Val Gln Lys Ile Ile Gln
GTT TGC CTT GAC CCT GAA GCC CCC CTG GTT CAG AAA ATC ATC CAA

Lys Ile Leu Asn Lys Gly Lys Ala Asn OP
AAG ATA CTG AAC AAA GGC AAG GCT AAC TGA CCTGGAAAGGAGGAGCCTGGG

CTGCTGTCCCTCAACGGAAGAACCAAAGAGAAAGAAAAAACAACAGCACCCGGGAAGC

CTGGATCGTIACCTGATGTGCCTCGCTGTCTGAGAGTTCACCTATTTATTTATCTATGTAT

TTT.TTTATTTATTAATTCCATTGCCAGATGTTGTTATGTTTATTATGATATTTAAAGAT

ATCGATTGCTAATTCACCTGTAATATCTTAAAGGTCATTTTAATATGTTAAAGTTTATT

TTAATAATGTTTAATGTGTTCAATTAAAGTTATTTAACTTATATAGTTGGAAGGTGATAC

ATTTTAAACCTATTTATTCATTAGTTTCTGGGGAGAGGGTGAGTTGGGAAGTAGCTACA

TCCCACCCACACAGTGAAAGAGACTGGGGATAAGGGGTGGGGGTGGGGACAAATAGATGC

AGTCGGATGGCTTTTCATGGAAGTAGTGTGCATGTTACATCATTTTTTTGTAAGCACCGA

GGAGAGTAGAACAGCTGTTATTTAGGTTTCAGTGTGTTGTAACTGTATGTACAACATTTT

TGATGCTGGATTTCAATGTAATGTTGTGAGTAACCCTTGGACATTTTATGTCTTCTCTCGT

AAGGCACAGTGCCTTGCTTAGCAATTGTTTTGTCATGCCTTTTCGTGTCTTGAGTGGAC

ACATTTATTTATTCATGTATTTTTACAAATAACAAAAATAAAAAACGTCTGTAAAAAAA

AAAAAAAAAAAAAAAAAAAA

FIG. 7

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US 89/03798

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC: IPC5: C 07 K 15/06, 7/10, 15/28; C 12 P 21/00; A 61 K 39/395 37/02; G 01 N 33/53														
II. FIELDS SEARCHED <div style="display: flex; justify-content: space-between; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;"> Classification System Minimum Documentation Searched † </div> <div style="display: flex; justify-content: space-between; border-bottom: 1px solid black; margin: 5px 0;"> IPC5 C 07 K </div> <div style="border-bottom: 1px solid black; margin: 5px 0; font-size: small;"> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ‡ </div>														
III. DOCUMENTS CONSIDERED TO BE RELEVANT † <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <thead> <tr> <th style="width: 10%; text-align: left; padding: 2px;">Category *</th> <th style="width: 70%; text-align: left; padding: 2px;">Citation of Document, †† with indication, where appropriate, of the relevant passages ‡‡</th> <th style="width: 20%; text-align: left; padding: 2px;">Relevant to Claim No. ‡‡</th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top; padding: 5px;">P, X</td> <td style="vertical-align: top; padding: 5px;">Proc. Natl. Acad. Sci. USA, Immunology, Vol. 86, January 1989, Stephen D. Wolpe et al: "Identification and characterization of macrophage inflammatory protein 2 ", see page 612 - page 616 --</td> <td style="vertical-align: top; padding: 5px;">1-9,21-29</td> </tr> <tr> <td style="vertical-align: top; padding: 5px;">A</td> <td style="vertical-align: top; padding: 5px;">J. EXP. MED., Vol. 167, February 1988, Stephen D. Wolpe et al: "Macrophages secrete a novel heparin-binding protein with inflammatory and neutrophil chemokinetic properties ", see page 570 - page 581 --</td> <td style="vertical-align: top; padding: 5px;">1-37,41,42</td> </tr> <tr> <td style="vertical-align: top; padding: 5px;">A</td> <td style="vertical-align: top; padding: 5px;">J. EXP. MED., Vol. 167, June 1988, George Davatelis et al: "Cloning and characterization of a cDNA for murine macrophage inflammatory protein (MIP), a novel monokine with inflammatory and chemokinetic properties ", see page 1939 - page 1944 --</td> <td style="vertical-align: top; padding: 5px;">1-37,41,42</td> </tr> </tbody> </table>			Category *	Citation of Document, †† with indication, where appropriate, of the relevant passages ‡‡	Relevant to Claim No. ‡‡	P, X	Proc. Natl. Acad. Sci. USA, Immunology, Vol. 86, January 1989, Stephen D. Wolpe et al: "Identification and characterization of macrophage inflammatory protein 2 ", see page 612 - page 616 --	1-9,21-29	A	J. EXP. MED., Vol. 167, February 1988, Stephen D. Wolpe et al: "Macrophages secrete a novel heparin-binding protein with inflammatory and neutrophil chemokinetic properties ", see page 570 - page 581 --	1-37,41,42	A	J. EXP. MED., Vol. 167, June 1988, George Davatelis et al: "Cloning and characterization of a cDNA for murine macrophage inflammatory protein (MIP), a novel monokine with inflammatory and chemokinetic properties ", see page 1939 - page 1944 --	1-37,41,42
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ††</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" ex. or document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p> </div> </div>														
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <tr> <td style="width: 50%; padding: 5px; vertical-align: top;"> Date of the Actual Completion of the International Search 22nd January 1990 </td> <td style="width: 50%; padding: 5px; vertical-align: top;"> Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.2em;">- 6. 02. 90</div> </td> </tr> <tr> <td style="width: 50%; padding: 5px; vertical-align: top;"> International Searching Authority <div style="text-align: center; font-weight: bold;">EUROPEAN PATENT OFFICE</div> </td> <td style="width: 50%; padding: 5px; vertical-align: top;"> Signature of Authorized Officer <div style="text-align: right;"> C.D. v.d. Vliet </div> </td> </tr> </table>			Date of the Actual Completion of the International Search 22nd January 1990	Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.2em;">- 6. 02. 90</div>	International Searching Authority <div style="text-align: center; font-weight: bold;">EUROPEAN PATENT OFFICE</div>	Signature of Authorized Officer <div style="text-align: right;"> C.D. v.d. Vliet </div>								
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
P,A	J. EXP. MED.; Vol. 168, December 1988, Barbara Sherry et al: "Resolution of the two components of macrophage inflammatory protein 1, and cloning and characterization of one of those components, macrophage inflammatory protein 1 β ", see page 2251 - page 2259	1-37,41, 42
	--	
P,A	SCIENCE, Vol. 243, February 1989, George Davatelis et al: "Macrophage Inflammatory Protein-1: A Prostaglandin-Independent Endogenous Pyrogen", see page 1066 - page 1068	1-37,41, 42
	--	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☒ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☒ Claim numbers 38-40 because they relate to subject matter not required to be searched by this Authority, namely:

Method for treatment of the human or animal body by therapy.
Rule 39 (iv).

2. ☐ Claim numbers because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.